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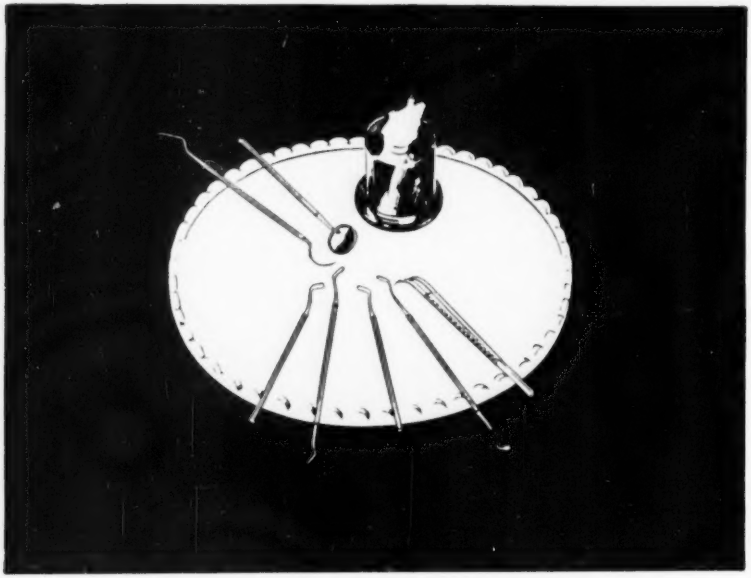

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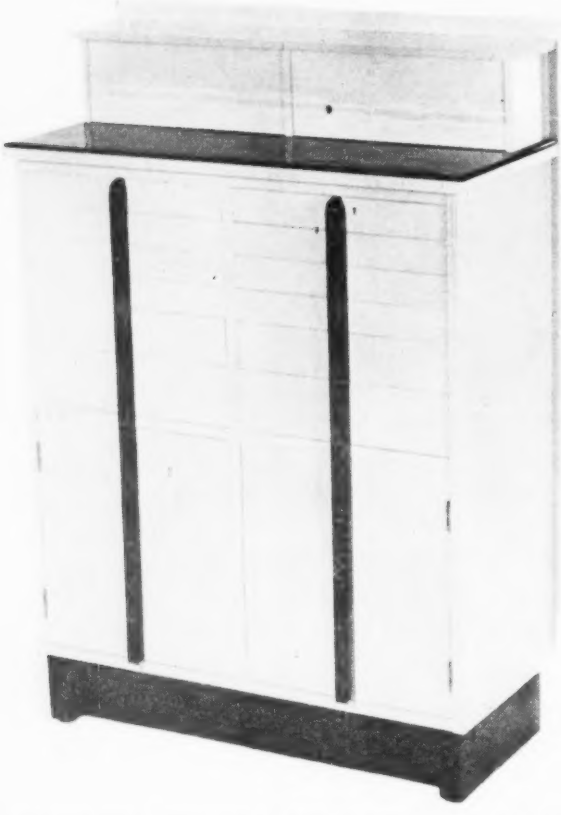

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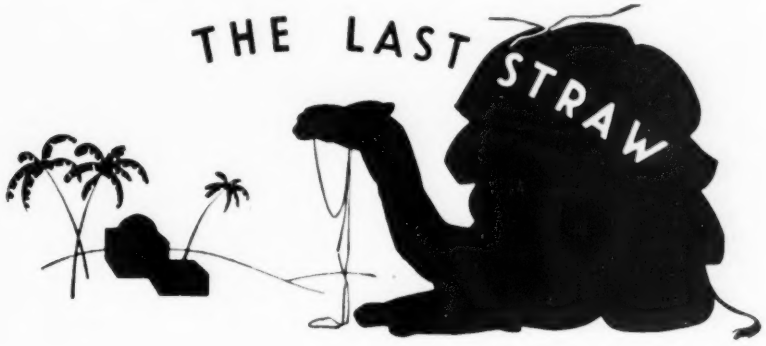

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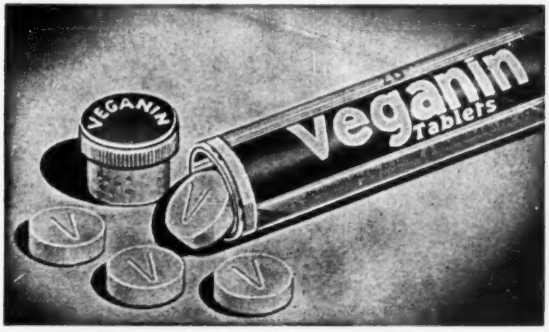

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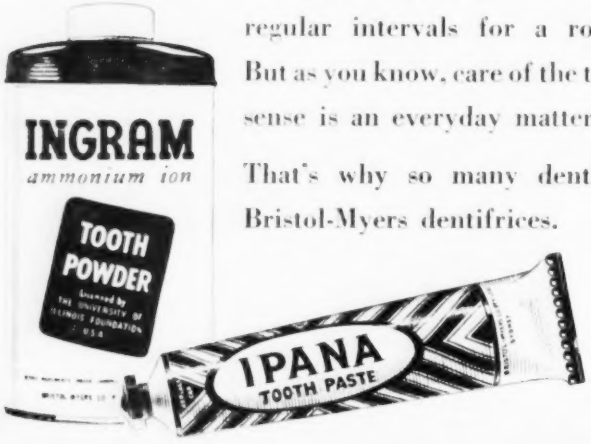

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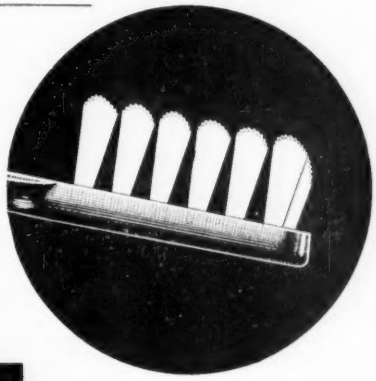

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Volume 25 December, 1952 No. 11-12

The DENTAL Journal OF AUSTRALIA

An Essentially Practical Approach to Pulp Capping and Pulpotomy*

W. D. Suthers, B.D.S. (Syd.), D.D.S. (N.U.)†

Introduction.

The treatment of vital exposed dental pulps presents few difficulties if fundamental principles are observed and due care is taken in the diagnosis and selection of cases.

The presentation of all relevant information will clarify the issue for the busy practitioner, and help to eliminate some of the embarrassing failures which occur. Most of the failures are due not to faulty technique or procedure but to a wrong decision regarding treatment. The techniques of pulp capping and pulpotomy give the dental surgeon a wonderful opportunity of preserving the health and vitality of teeth with exposed pulps, but their limitations must be realised.

The subject will be considered under the following headings:—

1. Rationale of treatment.
2. Drugs and materials used.
3. Simple practical procedures for pulp capping and pulpotomy.
4. Diagnosis and case selection.

1. Rationale of Treatment.

An exposure of the dental pulp may be caused by fracture of the crown of the tooth (especially the permanent incisors), by caries, or by instrumentation during cavity preparation.

Of these three causes, carious exposure of the pulp (deciduous and permanent teeth) occurs most frequently, followed by traumatic exposure of the permanent incisors and, least common of all, accidental exposure during cavity preparation. Accidental exposure is likely to occur in deciduous molars due to the large pulp chambers and prominent cornua.

The technique of pulp capping is simple and aims at the protection of the exposed pulp from bacterial infection, thermal change and chemical irritation. The success of this operation depends on the recuperative powers of the dental pulp and on the ability of the odontoblasts to form a layer of calcified tissue at the site of the exposure for, as Hess[1] has said:

> Treatment of an exposed healthy pulp consists in protecting the pulp by a biological wound dressing under aseptic conditions, so as to give the pulp tissue a suitable environment for repair.

Briefly, the technique consists of the following steps:—

(a) Isolation and drying of cavity.

(b) Application of capping material without pressure.

(c) Protection of this capping material with a thin mix of oxyphosphate cement.

Pulpotomy may be defined as the partial removal of the pulp or the removal of the coronal portion of the pulp. This technique aims at the removal of the infected portion of the pulp in the hope that the amputated pulp stumps in the root canal or canals will remain vital and that any inflammation present will resolve, once the source of infection is removed.

Once again the success of the operation depends on the recuperative powers of the pulpal tissue and the formation of a "dentine bridge" which will effectively seal off the pulp at the site of amputation.

*Based on a lecture delivered to a meeting of the Australian Dental Association, New South Wales Branch, on 25th March, 1952.

†Lecturer in Pedodontia, University of Sydney.

Of vital importance in a young tooth is the fact that a successful pulpotomy operation, and the maintenance of pulp vitality in the root canal, will allow normal root formation to continue until the apex is closed.

The technique consists of the following steps:—

(a) Anaesthesia of the pulp.

(b) Isolation of the field.

(c) Removal of carious dentine and sterilisation of the cavity.

(d) Opening into the pulp chamber and amputation of the pulp.

(e) Control of haemorrhage.

(f) Insertion of the capping paste.

(g) Oxyphosphate cement flowed over the capping material.

2. Drugs and Materials Used.

Choice of a capping material is the first and main consideration. Most of the recent research work in this field has been devoted to a study of the effect of capping materials on the exposed or amputated pulp. These investigations were stimulated by the discovery that the vital pulp was capable of forming a protective layer of calcified material.

In the past, countless materials have been used and advocated, and for convenience they will be divided into three groups.

Group 1.

Zinc oxide and eugenol, a crystal of thymol, thymol-zinc oxide, zinc oxide-iodoform-eugenol, copper cement, zinc oxyphosphate cement with silver nitrate or eugenol incorporated in cement liquid, are representative of this group.

Most of these materials were assumed to have a combined sedative and germicidal effect on the exposed pulpal tissue.

Group 2.

Powdered ivory, dentine splinters and dentine powder.

The use of finely powdered, sterilised ivory and dentine powder is based on the assumption that the formation of a calcified layer will be encouraged by the presence of these particles, and that dentine will be deposited around them. Manley[2] believes that the particles may act as "organizers" causing cells to assume an osteogenic function as do bone chips in a bone graft.

The sterility of the particles has always been a major difficulty, and some workers have incorporated dentine powder in a sulphacetamide ointment to combat the possibility of infection.[3, 4]

Group 3.

Calcium hydroxide (in powder form).

Paste of calcium hydroxide and water.

CALXYL, SEROCALCIUM, DENTINIGENE and REOGAN.

Materials with calcium hydroxide as the base have been used to cap pulps as far back as 1920, in the belief that the production of an alkaline reaction in the area would encourage the deposition of dentine.

The autoclaved calcium hydroxide can be insufflated on to the exposed pulp tissue in powder form or applied as a paste.

The proprietary pastes mentioned have a calcium hydroxide base, which is modified by the addition of certain salts. For instance, CALXYL is a white, slightly radio-opaque paste composed of calcium hydroxide with some salts of the human blood serum, $NaHCO_3$, $CaCl_2$ and KCl, giving a pH of about 11. The serum salts bring about a better toleration of the $Ca(OH)_2$ with its high pH of more than 12.

The advantages claimed for CALXYL are:—

(i) bactericidal;

(ii) neutralisation of acid by-products which follow an injury, will facilitate healing.

(iii) stimulative influence on odontoblasts;

(iv) due to alkaline reaction, it increases the activity of the enzyme phosphatase.[5]

Successful clinical results have been claimed in dental literature for materials in all groups, and it is very difficult to evaluate their effectiveness.

Two reports of materials from Group 1 will illustrate this point.

Jamesson[6] in 1948 reported the treatment of at least 1,000 exposed pulps in the previous 12 years with about 95% success. He advocated the use of thymol because of its sedative as well as bacteriostatic and bactericidal properties, and used a thymol zinc cement as the capping material.

Rosenstein[7] in 1942 presented a complete report of 628 cases of pulp capping in deciduous teeth over a 9 year period with a 90% successful response. The pulp capping materials were zinc oxide and eugenol, thymol and zinc oxide, copper cement with special silver nitrate liquid, and copper cement with regular liquid.

The above figures are very convincing although the pulp cappings were evaluated on a clinical and radiographic basis only.

The second group of materials have been used mainly by European workers, with good clinical results.

Mueller[8] experimented with finely powdered, sterilised ivory mixed in a 5 per cent. solution of vioform in alcohol. Microscopic examina-

tion of the pulps made one year after they had been capped with this material showed 55% satisfactory results, but clinically the results were 80% successful.

Dentine powder has also been used extensively as a capping material. Shaw[3] incorporated the powder in ALBUCERATE* (a sulphacetamide) and Gottlieb[4] suggests a dentine-sulphathiazole salve.

The third group of materials all have calcium hydroxide as the base and, as sterility is no problem, they have a decided advantage over the previous group.

Hermann[8] was the first to use $Ca(OH)_2$ for capping exposed dental pulps in the early twenties, and introduced CALXYL. Investigations showed that pulpal repair and the formation of secondary dentine was encouraged by these materials.[1]

The work of Glass and Zander[9] in the United States in 1949 focussed world-wide attention on the significance of calcium hydroxide as a capping material. In an endeavour to discover under what conditions an exposed healthy pulp was capable of healing, they mechanically exposed the pulps of forty sound teeth and capped them with a paste of either zinc oxide and eugenol or calcium hydroxide and tap water. These teeth were extracted after periods of time varying from 24 hours to eight weeks, sectioned, and the pulps examined microscopically. The pulps capped with zinc oxide and eugenol exhibited an area of necrosis around the exposure point, surrounded by a chronic inflammatory zone which persisted even after the eight weeks. There was not the slightest indication of secondary dentine formation. The pulps capped with calcium hydroxide exhibited an area of necrosis around the exposure point and a less severe inflammatory reaction in the surrounding pulp tissue which rapidly disappeared. There was microscopic evidence of secondary dentine formation after two weeks and a distinct and well-formed dentine bridge protecting the vital pulp tissue after eight weeks.

These findings throw suspicion on the clinical results claimed for capping materials in Group 1, but the explanation is provided by Tananbaum[10] in a recent experiment. The pulps of 128 deciduous and permanent teeth were capped with either zinc oxide-eugenol paste or calcium hydroxide paste and 116 were successful and in place from five to 39 months. The teeth treated with zinc oxide and eugenol showed an 89% success, those with calcium hydroxide a 92% success. Only 4% of the zinc oxide-eugenol group showed a secondary dentine barrier radiographically after two years, while 89% of the calcium hydroxide group showed this barrier within one year.

Choice of a sterilizing agent.

When pulp exposure occurs under clinical conditions, the field is invariably contaminated by bacteria, and the operator has an almost irresistible urge to sterilize the dentine and pulp tissue by means of some antiseptic.

Although it is desirable that these organisms should be eliminated, we must consider the effectiveness of any antiseptic used in relation to two factors: (a) its effect on the pulp tissue; (b) the depth to which it is able to penetrate.

A pledget of cotton wool moistened with phenol is often advocated.[7, 11] Jamesson[6] recommends a thymol-alcohol mixture. Other drugs mentioned in literature are hydrogen peroxide, eugenol, zephiran (1 in 100), metaphen, 2-3% iodine, etc. Cautery has also been used in an attempt to eliminate bacteria in the superficial layer of the exposed pulp tissue.

It is obvious that all these measures will cause inflammatory reactions in the underlying pulp, and there is no positive way of determining their effectiveness. It would seem more logical to use some bland and non-irritating drug which would not impair the pulp's ability to lay down secondary dentine.

Mechanical cleansing of the field with warm physiological saline, a concentrated solution of calcium hydroxide, or a 2-3% solution of CALXYL is suggested. The CALXYL solution is claimed to have a bactericidal effect.

Choice of a haemostatic agent.

Amputation of a vital pulp usually results in profuse haemorrhage, especially if the pulp is hyperaemic. This must be controlled before a capping material is inserted and to obtain a clear view of the pulp chamber.

The main drugs used are adrenalin hydrochloride (1 in 500 solution), hydrogen peroxide, camphophenique, phenol, topical thrombin preparation, a saturated solution of calcium hydroxide, and a solution of CALXYL.

Though all these drugs will control the haemorrhage if used in conjunction with pressure, applied on a pledget of cotton wool, the agent should be readily tolerated by and non-injurious to the pulpal tissue. The use of calcium hydroxide or CALXYL fulfils this requirement and simplifies the technique by reducing the number of drugs needed.

Insulating material between capping material and cement base.

A layer of paraffin wax or neutral varnish may be used to prevent interaction between

*Schering.

the alkaline $Ca(OH)_2$ and any free phosphoric acid liberated from the oxyphosphate cement.

A creamy mix of zinc oxide and eugenol can also be used as the insulating medium.

Though this step is theoretically sound, experience soon demonstrates that it is no easy matter to place these materials accurately in position over the capping paste, when performing a pulpotomy in a deciduous molar and, in the case of an exposure in a traumatized anterior tooth, it is almost an impossibility.

An insulating layer is suggested when doing a pulpotomy in a permanent molar, but otherwise this step is omitted.

3. Simple Practical Procedures for Pulp Capping and Pulpotomy.

Pulp capping.

The procedure for a traumatic exposure in a permanent anterior tooth will be described.

(i) A case history recording details of the accident, symptoms, time of exposure, haemorrhage, etc., should be made.

(ii) Radiographs and vitality tests with electric pulp tester are essential for comparison with similar radiographs and tests at the periodic check-up examinations.

(iii) The tooth should be isolated with rubber dam, if possible. Where the fracture line extends beneath the gingivae, a copper band can be fitted and then cemented into place before applying the rubber dam.

(iv) The tooth is washed with warm saline, and the fracture area cleansed with a pledget of cotton wool moistened with $Ca(OH)_2$ in solution or CALXYL solution and dried with warm air.

(v) A soft paste of $Ca(OH)_2$ or CALXYL is applied over the exposure but not extending beyond the dentine. This soon hardens and a creamy mix of oxyphosphate cement is teased over the capping material with an explorer or wire loop, covering the entire fracture area.

(vi) A suitable celluloid or acrylic crown form is selected and trimmed to fit accurately at the gingival. When fitted, the occlusion should be checked to make sure the tooth will not suffer further traumatic injury during functional movements of the mandible. If much tooth structure is lost and retention of the crown is doubtful, it is better to fit a copper band or orthodontic band, rather than risk the early loss of the crown form and possibly the capping materials. In any case the cement cap should be lubricated before cementation of crown form or band. Oxyphosphate cement or synthetic porcelain can be used to fill the crown.

(vii) Two small holes drilled through the crown form to the lingual of the incisal edge will aid in its retention and allow the escape of excess material. If the plastic crown form is selected, a self-curing acrylic of the appropriate shade can be used to fill it. A rest period of six to eight weeks is indicated before further vitality tests and the placing of a semi-permanent restoration.

Pulpotomy.

The procedure for a deciduous molar will be described. It is assumed that the pulp is vital and suitable for pulpotomy.

(i) A radiograph is necessary to determine the condition and for purposes of comparison later.

(ii) All instruments and drugs should be laid out ready for immediate use, including a container with sterile cotton wool pellets.

(iii) Infiltration, conduction or intra-osseous anaesthesia may be used, but pressure anaesthesia is contra-indicated owing to the risk of forcing bacteria even deeper into the dental pulp.

(iv) The maintenance of a dry and sterile field is essential and the tooth must be isolated by rubber dam or cotton rolls. With young children the use of cotton rolls changed as often as necessary is more practicable than the use of rubber dam.

(v) The whole field should be swabbed with tincture of iodine 25% or zephiran (1/100). After gross caries is removed from the cavity, it should be swabbed again with the sterilising agent to prevent contamination of the pulp chamber during the operation. Wide access must be gained on the occlusal aspect, and dentine removed until only a thin layer of dentine forming the roof of the pulp chamber remains. A fresh sterile fissure bur is then used to remove this thin layer and open up the pulp chamber. The pulp tissue in this chamber can be amputated with suitable sharp excavators or a No. 6 rosehead bur can be used. A rapidly revolving bur is effective more quickly but there is a possibility that the tissue in the vital stumps may be torn or twisted, this interfering with their regenerative powers.

Removal of debris and control of haemorrhage may be achieved by using a pledget of cotton wool moistened with CALXYL or a saturated solution of $Ca(OH)_2$, but if bleeding persists the pulp chamber should be packed with a pledget soaked in adrenaline hydrochloride (1:500). A stiff paste of $Ca(OH)_2$ or CALXYL, at least 2 m.m. thick, should be placed over the amputated stumps, and a creamy mix of oxyphosphate cement folded over this

to fill the cavity. Particular care must be taken to remove any capping material from the gingival margin, and also to make sure that the cement filling is out of occlusion. If necessary, the amalgam restoration can be inserted at the same visit, though a waiting period of one to two weeks is desirable.

CRITERIA OF SUCCESS.

Pulp capping:

1. History of pain.
2. Tenderness to percussion.
3. Response to electric pulp tester.
4. Periapical findings.
5. Deposition of secondary dentine.

Pulpotomy:

1. History of pain.
2. Tenderness to percussion.
3. Vitality tests (useless).
4. Continued root formation (permanent teeth).
   Continued root resorption (deciduous teeth).
5. Deposition of secondary dentine.

4. DIAGNOSIS AND CASE SELECTION.

PULP CAPPING.

A study of dental literature will not clarify the vexed question, "When should pulp capping be attempted?" From the evidence of Fish[12], Kronfeld[13], and Gottlieb[4], it seems clear that if an exposure occurs clinically the pulp must be infected, and if infected then capping the exposure is a deliberate enclosure of infection within the pulp chamber. The operator cannot assess the degree or extent of infection and inflammation accurately, and pulp capping in these circumstances is to be condemned. On the other hand, there is a large amount of clinical evidence (some of it already quoted) giving proof of successful results following capping of both accidental and carious exposures. In other words, the purist will cap nothing but a pulp exposed aseptically and demand microscopic proof of success, while the realist will assess the factors involved and cap many exposures which experience tells him will probably result in a success clinically.

The following factors should be considered in the selection of cases:—

1. Sensitivity of pulp and reaction to vitality tests.
2. Slight haemorrhage of pulp at point of exposure.
3. Absence of periapical area of rarefaction in radiograph.
4. Negative history of chronic disease.
5. Negative history of intense, prolonged pain in the tooth involved.

In the case of traumatized anteriors, the time the pulp has been exposed is an important factor. If exposed over fifteen to eighteen hours, Ellis[14] considers that capping is contra-indicated. As pulpotomy is a very satisfactory alternative to pulp capping, and success is more certain, it is good clinical procedure to limit pulp capping to exposures of instrumental origin and utilise the pulpotomy technique in other cases.

PULPOTOMY.

(a) *Deciduous teeth.*

A carious exposure in the deciduous dentition is best treated by performing a pulpotomy unless the child is unco-operative and difficult to control. The following diagnostic factors should be considered in the selection of cases:—

(i) Negative history of toothache or attacks of intermittent toothache only. (No prolonged or intense pain.)

(ii) Absence of periapical area of rarefaction in radiograph.

(iii) Haemorrhage of pulp at point of exposure.

(iv) Sensitivity of dentine to bur and/or sensitivity of pulp when touched with explorer.

Three other general factors influencing selection of cases are:—

(v) General health of patient.

(vi) Time of exfoliation of tooth and expected period of service.

(vii) Condition of other teeth, caries susceptibility, and whether preservation of the tooth in question is warranted.

In the light of clinical experience, several pulpotomies in one mouth are best avoided, unless absolutely sure that they will be successful. It is often better to extract the doubtful and most broken down teeth in one arch, make a space maintainer, and concentrate on preserving the other arch intact.

(b) *First permanent molars.*

The same diagnostic factors must be considered, and also the condition of the other three first permanent molars and their probable length of service. Even if extraction of all the first permanent molars is contemplated, a pulpotomy may be desirable as an interim

measure to preserve a molar and so maintain the vertical dimension until the bicuspids erupt.

(c) *Traumatized anterior teeth.*

In the case of young permanent teeth with wide open apices, pulp exposure is best treated by pulpotomy if there is the slightest doubt about the degree of infection or contamination. In particular, pulpotomy is indicated when the following conditions are present:—

(i) Extensive exposure of pulp.

(ii) Extensive haemorrhage.

(iii) Pulp exposed for longer than 24 hours.

(iv) Root end still in process of development.

However, the pulp must be still vital. It should respond to an electric vitality test, and be sensitive when gently wiped with a pledget of cotton wool.

In cases where the root apices are wide open and there has been a long exposure of the pulp, penicillin therapy is suggested to help control infection and to create the optimum conditions for success.

Conclusion.

These techniques merit a place in the field of conservative and preventive dentistry, but more advanced diagnostic methods are required so that the condition of an inflamed pulp can be assessed accurately. Increasing knowledge of pulpal reactions to various drugs and capping materials has resulted in many pulp capping techniques being outmoded. The pulpotomy technique should be used more frequently when carious exposures in permanent teeth are encountered, even in adult patients.

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Complete Mouth Rehabilitation*

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Many noteworthy papers have been written on the subject of Complete Mouth Rehabilitation—some encouraging this work, others discouraging its performance. This dissension, or conflict of opinion, is readily understood when we consider the events that have led up to our present day understanding and practice of this important, broad field of complete rehabilitation of the mouth.

At the outset, the misnomer "bite raising" or "bite opening" created considerable scepticism in the profession. These terms led to a fear that indiscriminate opening of bites would result in harmful and detrimental alterations in the oral cavity, as well as in the region of the temporomandibular joint. A principal concern was the fear that bite raising might institute a procedure for unrestrained bite opening, beyond the normal limits of what we know today to be the physiologic rest position of the mandible. There was a substantial foundation for these fears because, not being acquainted with, much less aware of the existence of, a physiologic rest position, freeway space, or vertical dimension, there was a very real chance that harmful results might occur.

As early as 1920, Monson[1] had foreseen that some definite way should be devised to correct bite anomalies in adults. He pioneered in this direction and recognized the possibilities of onlays, pin-onlays and splints. How-

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ever, his approach and endeavours were not too successful, since the techniques and the underlying theories he employed were not fundamentally sound. Briefly, his method consisted of utilizing pin onlays as a means of raising a bite. In this procedure the teeth were not prepared as for an inlay but, instead, grooves or pin-holes were made in each tooth that was to be utilized in opening the bite. Onlays with pin attachments were then constructed to fit over the teeth and into the prepared pin-holes. The individual pin onlays were next soldered together into one unit, to form a single span over a succession of teeth. Of course, as we know today, this was an unsound method and proved to be unsuccessful. Hygienically, it was poor dentistry, permitting food to accumulate and allowing periodontal disturbances to develop, and subsequently resulting in a greater susceptibility of the teeth to decay. Of even greater significance and importance was the complete disregard for the prevailing forces that are constantly functioning in the complex mechanism of the masticatory apparatus. The resultant effect was an improper balance, and an uneven distribution of the forces and stresses involved. In practice this meant that a series of teeth could become affected, rather than a single tooth if a single tooth unit had been employed. Subsequently there was prevalent loosening of teeth, depressing of teeth and disturbance in the region of the temporomandibular joint area. It is understandable, therefore, why, even today, some men are still reluctant to accept the new and scientific theories and methods we now employ to rehabilitate a mouth.

This phase of dental procedure was further jeopardized, however, when it became exposed to the unscrupulous dental laboratories. The laboratories, much less conscientious, naturally, than the dental profession, capitalized on the commercial possibilities which they were prompt to detect. Utilizing gold or chrome splints and onlays, they raised bites indiscriminately without any knowledge whatsoever of physiology, anatomy, pathology or dentistry. No small wonder that men of science were sent running in the opposite direction, fearing the outcome.

However, in spite of all these failures and shortcomings that were inevitable at first, Monson, and others who pioneered with him, should be commended for having prepared the profession to think in the right direction, resulting in the research that is necessary to analyse and solve this vital problem. At least these men were aware that something was wrong.

This line of thought and reasoning led to a period in which bite planes were being used indiscriminately to open bites. The primary reason for failure in this direction can be attributed to the fact that the bite planes were adapted in the mouth to function as permanent restorations. The results were much the same as those obtained with pin onlays. It was discouraging work. The bites closed in naturally because the occlusion was not properly established and balanced and because the forces were not evenly distributed. The bite opening was accomplished by means of visualization, without the aid and benefit of precision instruments and scientific methods. Furthermore, being unaware of the existence of a physiologic rest position, overcaution was exerted in opening the bite so that bites were not opened to their full extent within the limits of the rest position. Consequently, with an improper balance that would gradually close in a bite anyway, coupled with an insignificant and insufficient amount of bite opening, little if any benefit was accomplished.

When the condition of the supporting alveolar structures and the teeth is sufficiently healthy to warrant fixed or permanent restoration, bite planes should not be employed as a permanent means of rehabilitating a bite. A bite plane should be employed as a temporary measure, remaining in the mouth from six months to one year. When such a restoration is used as a permanent fixture, the teeth may become depressed and loosened and periodontal disturbances may result. Fixed or permanent work should be instituted to replace temporary bite planes within a year.

However, in a case of periodontoclasia, where there is a destruction of alveolar bone and supporting structures, resulting from local trauma or due to interlocking cusps, bite planes may be retained for longer periods of time. In bites where these conditions are present, the use of a bite plane to open the bite will relieve cuspal interferences, occlusal discrepancies, balance the occlusion, and stimulate and aid the supporting bone and tissues. In these cases a bite plane may serve its purpose and remain in the mouth for longer periods of time. In time there may be a cessation of the active process of bone destruction and an arrested bone condition. Later, we may observe areas of bone condensation along the alveolar crest. And, considering other factors such as the teeth and soft tissues, it is possible to decide at this time if fixed or permanent work is advisable. However, in those cases where the active process of bone destruction has not been arrested, the bite plane may be maintained indefinitely. It must be kept under constant observation and control, with

necessary adjustment made to maintain proper balance. In these cases it would be impractical to institute permanent or fixed restorations. The prognosis is not always favourable but the author has watched and treated a number of such cases successfully.

Forces that are continually being activated in the mouth become dangerous when left out of consideration in the construction of dental restorations because, wherever forces are applied, leverage arrangement occurs. Thus, in bite planes or in removable appliances, if added force is applied at one end where a tooth is malocclueded, it will produce a force at the other end. (See figure 1.) Often this resultant force is larger than the applied force, due to leverage magnification. This is particularly true in removable work which often has elements connected by lingual or palatal bars of considerable length with clasps necessary for retention. For example, a removable appliance, which has a bar connecting from a molar on one side of the arch to a molar on the other side, acts as a lever with a length equal to the full width of the mouth. (See figure 2.) A force applied at one side will, therefore, produce a force on the other side which may be several times larger due to leverage multiplication. Excessive forces are produced which loosen teeth, injure the periodontal tissues, and cause a general breakdown of the underlying structures. A pull in one direction is necessarily transmitted to and exerted on all these teeth, acting on the same principle as an orthodontic appliance. When bite opening is accomplished, utilizing single units on each tooth wherever possible and regarding each tooth as an individual entity, it is obvious that each tooth will act individually and independently to its own pull and force, rather than be subjected to the pull of an entire unit or a large segment.

The next stage in the course of bite raising was a process of opening bites gradually or by degrees. In this procedure, aluminium or soft gold crowns were used to raise the bites. The method consisted of building up the crowns gradually so as to accommodate the patient to the proposed increase in the vertical dimension. After remaining in the mouth a specified time, perhaps a month or two, the crowns were removed and slight additional vertical height was created on the restorations. This method was unsuccessful, however, due to the malleability of the material utilized, the lack of balance obtained and the insufficient amount of vertical height restored. The results of this treatment, it appears, defeated its purpose for before additional opening could be created on the crowns, the bite had already been permitted to close in to its original position so that the end results were neither constructive nor satisfactory. Bite revision in which the restoration of lost vertical dimension is required must be accomplished at one time, and the bite must be restored with an appreciable amount of lost opening if results are to be permanent and practical.

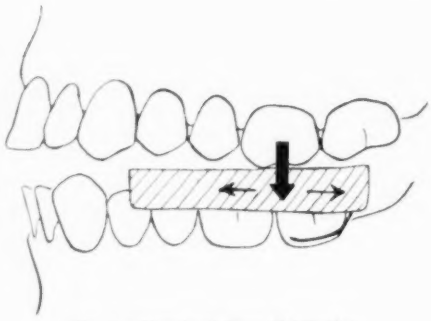

Fig. 1.—Directional force distribution.

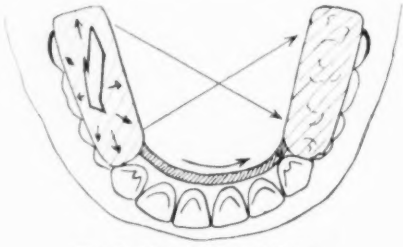

Fig. 2.—Magnification of forces.

Vertical dimension can best be described as the vertical height of the face determined and established by using a physiologic rest position of the mandible as a guide. Therefore, the most important factor in determining vertical dimension is a theoretical and practical working knowledge of the physiologic rest position.

Early investigation in this work was based on a theory that the relation of the teeth in occlusion was responsible for the mandibular position and, consequently, that the vertical dimension or vertical height of the face was determined by the relation of the teeth.

The first departure from this concept was the theory expounded by Niswonger[2] in 1934, that the position of the mandible is dependent on the musculature. This deduction was based on the reasoning that there is a physiologic rest position of the mandible, and that this position determines the height of the face. Niswonger defined it as

> that position of the mandible in which it is involuntarily suspended by the reciprocal co-ordination of the muscles of mastication and the depressor muscles, with the upper and lower teeth separated.[2]

This concept has proved to be the cornerstone on which the science of mouth rehabilitation has been built. Investigations have proved that the physiologic rest position is fixed and constant. Since the musculature and not the teeth determines the position of the mandible, this rest position is established long before any teeth are present and there is evidence that it exists after they have been lost. It is recognized that the muscles do not change in length. They may vary in tone or activity but their length remains constant throughout life. The basic factor must be kept in mind in considering increases in vertical dimension. It is particularly significant that since the mandible assumes its relation to the skull early in life, the vertical dimension of the face is necessarily established at the same time and remains proportionately constant throughout life. Therefore, treatment of a closed bite is not designed to increase the vertical dimension, inasmuch as this would imply an increase beyond the normal, but is intended as a means of restoring the amount of vertical dimension that has been lost.

The investigations which substantiated this theory were made possible by the development of a roentgenographic cephalometric method for the accurate study of the mandibular movements. The technique consists of positioning the head in a fixed reference frame and of standardizing all the component factors: the central ray, the position of the head and the x-ray film. Roentgenograms and tracings of the successive positions of the mandible then may be obtained for accurate comparative study.

The roentgenographic cephalometric method of study of the head, its pattern of growth and changes, was made possible in 1931 by Broadbent.[3] Investigations by Thompson and Brodie[4] in 1942, employing this method, have shown that the position of the mandible in relation to the head is established by the third month of life, and that this relation is not altered by growth. In addition, in reporting on complete anodontia, they point out that the position and relation of the mandible to the maxilla is maintained by the muscular attachments, and is not in any way dependent on the teeth.

Further investigations on the rest position in growing persons, orthodontic patients, edentulous patients and full and partial denture patients showed that the exact similarity of the facial proportions, established with the mandible at rest, indicates that the rest position remains constant as growth progresses, that it is a part of the inherent growth pattern of the face, and that it is unrelated to the presence or absence of teeth.[5]

These studies were vitally important. All the old theories and ideas had to be revised and these new concepts had to be studied and tried before they were accepted. There was still a great deal of scepticism, however. What would happen if the bite was actually raised beyond this rest position? What harmful results would this produce? How was this rest position to be determined and utilized?

The fear of raising a bite beyond the rest position is certainly understandable. Theories, telling a man that there is a rest position of the mandible and warning him to be aware of this position, are all well and good. The important factor from there is to make practical use of this rest position and to exercise care not to abuse it.

Using a roentgenographic cephalometric machine similar to that of Broadbent's, the author[6] instituted a practical investigation of cases in which he had completely rehabilitated the mouth. As a result of these studies, it was found that if a bite is raised within the physiologic rest position, there is little if any change in the condylar position.

Furthermore, it was observed and proved through cephalometric, clinical and radiographic studies of bite correction cases that there is no appreciable closure of the bite. In cephalometric tracings, it was observed that after a period of years bites restored with lost vertical dimension have not closed in more than might normally be expected in a mouth that is normal. What actually takes place is merely an accommodating position of the bite over a period of years. The fact that there has been insignificant closure of the vertical dimension is proof that the teeth themselves have not been depressed.

In cases where there has been an increase in the vertical dimension beyond the physiologic rest position of the mandible, the result is an undue strain on the musculature, stretching the muscles beyond their normal length. The strain on the muscle produces pain, discomfort and constant muscular tension. It has been observed in natural dentition as well as in edentulous patients, that after a substantial period of one to two years, the muscles will return to their normal length, but only after a sacrifice has been made through the development of detrimental changes in the oral cavity. The return of the strained musculature to normal length will be effected by a resorption of the underlying alveolus and surrounding tissues, resulting in possible loosening or depression of the teeth and gingival trauma. In other words, the muscles involved will resist this constant strain, and, as a result, will force the dentition into a new arrangement which permits the musculature

to assume a rest position that is comfortable as well as a sufficient amount of freeway space for function.

Stansbery,[7] in 1938, stated that a loss in vertical dimension results in the approximation of the origin and insertion of the masticatory muscles.

The important point of muscle function is that there is a critical point in the distance from the origin to the insertion at which the muscle can exert the greatest force in contraction. When the distance from origin to insertion is shortened, the muscle has less efficiency and the result is a loss in vertical dimension. When the muscle is stretched beyond the critical point, the efficiency is also reduced. When the distance is shortened the muscles have a tendency to lose tone. Muscles that are stretched beyond the normal tend to return to normal length, but at a sacrifice and with structural changes, unless the resistance is greater than the strength of the muscles. Muscles, therefore, function with maximum force when stretched to a critical length between the origin and insertion, together with proper leverage.

As a result of this investigation, it is recognized that the freeway space is that space existing between the physiologic rest position and the tooth contact position. (See figures 3 and 4.) Therefore, as the vertical dimension decreases with loss of teeth or with attritional wear of the teeth, the size of the freeway space between the mandible and the maxilla will increase. However, the physiologic rest position will remain constant, regardless of the condition or existence of the teeth in the oral cavity. (See figures 5 and 6.)

The freeway space may further be described as that interdental space that exists between the physiologic rest position and the physical contact position of the mandible in relation to the maxilla. It is that space that is found between the mandible and the maxilla, when the mandible is in its physiologic rest position.

Briefly, the physiologic rest position is a relaxed position of the supporting muscles above and below the mandible. Since it is dependent upon the musculature, it is a position that is always constant and it does not change with age or the presence or absence of teeth. It is always present and can always be located in young adolescents as well as in adults. However, due to age or the absence of teeth, the vertical dimension of the face is naturally altered, and may close in, but this in no way affects the physiologic rest position.

Freeway space, on the other hand, is dependent upon the relation of the mandible to the maxilla when the mandible is in its rest position. Therefore, if the vertical height of the face is decreased through wear of teeth or loss of teeth, the size of the freeway space is naturally increased. However, if the relative functioning position of the mandible is either at the physiologic rest position, or if it is in a functioning position beyond the rest position, this would mean that no allowance for a freeway space between the mandible and the maxilla exists. Translated into action, this would mean that the mandible must travel constantly beyond its rest position during the process of mastication, resulting in undue pull on the musculature and stretching the muscles beyond their normal length. The strain and pull on the muscles might produce pain, discomfort and constant tension. Adequate freeway

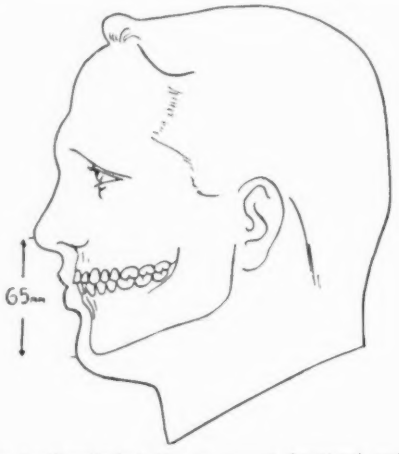

Fig. 3.—Hypothetical bite in normal functional occlusion. Vertical dimension measures 65 mm.

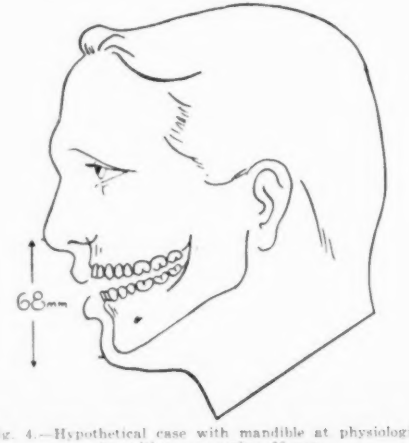

Fig. 4.—Hypothetical case with mandible at physiologic rest position, measuring 68 mm.

space is necessary for proper speech and in order to enable the patient to masticate food. In a mouth where the natural dentition has been rehabilitated, insufficient freeway space will result in a clicking of the teeth while in an edentulous mouth, the result will be a tipping and clicking of the dentures and a complaint that there is not sufficient room for food. The ridges will be sore, and the patient will refuse to tolerate the dentures in the mouth. Too great a freeway space, on the other hand, will result in a tipping of the dentures since the mandible must travel a greater distance to make contact with the maxilla. In rehabilitating a mouth, therefore, careful consideration must be given to a sufficient allowance for a freeway space. Roentgenographic studies by Mayes[5] and others have determined the freeway space to be close to the assumed value of 2 mm. in most cases. However, the exact amount of freeway space should be determined independently in each individual. The amount of freeway space to be allowed can be determined by the amount of vertical dimension that has been lost. It will be found that the greater the amount of vertical dimension lost, the more freeway space should be allowed.

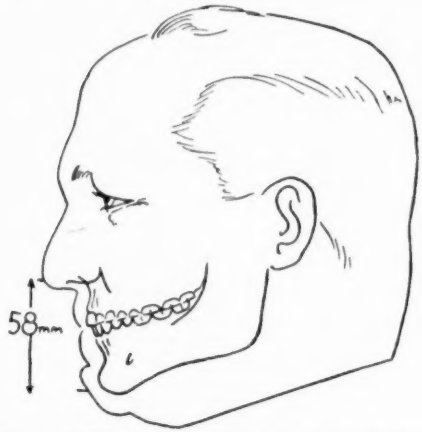

Fig. 5.—Hypothetical case showing extensive attrition that has developed over period of years. Compare with figure 3. Vertical height has closed in due to attritional wear on teeth.

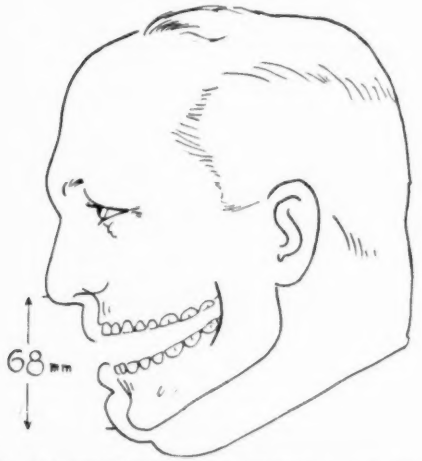

Fig. 6.—Hypothetical case with mandible at rest position. Compare with figure 4. Note that although the size of the freeway space between the mandible and maxilla has increased, due to the attritional wear on the teeth, the physiological rest position of the mandible has remained constant through the years.

It is also necessary to consider the age of the patient. A younger person will tolerate a greater increase in the vertical dimension and will become adjusted more easily to a decrease in the freeway space as necessitated by the new changes. However, it is advisable to make an allowance for more freeway space rather than to leave an inadequate amount.

In practice, the physiologic rest position, less a deduction for freeway space, will give you the physical or tooth contact position of the mandible. This position is the normal functional occlusion for the individual, determined from his own physiologic rest position.

The physiologic rest position may be referred to as the starting point of the biting action. During the normal process of mastication, the excursion of the mandible, or the chewing cycle, begins at the physiologic rest position and returns to the tooth contact position or to centric occlusion. The centric position of the teeth, therefore, may be referred to as the stopping point of the biting action.

In practice, the physiologic rest position is best determined by tiring the depressor muscles, and relaxing the mandible. There are several methods used to obtain this relaxed position of the mandible. Some men advocate a repeated swallowing action when the oral cavity is devoid of food. By repeating the swallowing action several times, it is claimed that a reproducible mouth opening is obtained. Phonetics, or certain letter and word sounds, made by the patient, such as *m* or *o*, or *Ohio*, or *Mississippi*, are claimed to aid in positioning the mandible at rest. Another method is an unrestrained lip contact, which is often combined with the phonetic test. However, this procedure may easily result in an inaccurate mandibular position. Some men allow the patient to determine the most comfortable position of the mandible. This, however, shifts the responsibility to the patient. A fifth procedure is a cephalometric method, but this is

not always practical since the equipment is not available to the average dentist.

To establish more accurately the physiologic position of the mandible at rest, a method based on measurement would be the logical answer. The method which I employ for locating the rest position of the mandible is, I feel, the closest approach to obtaining as near a normal and natural position of the mandible as is possible. I make this statement on the basis of clinical research and experience and on the gratifying results which I have obtained in cases of complete mouth rehabilitation.

In this procedure, the patient is seated upright in the chair, body and face perpendicular to the floor. At this time the mouth must be devoid of all dentures, bases, removable appliances or instruments. The patient is instructed to keep the mouth wide open until there is a noticeable quivering of the orbicularis oris muscles around the lips. Usually this quivering may be noticed in three to five minutes. The patient then closes, swallows and relaxes. The quivering of the lips is a fairly sound indication that the orbicularis oris muscles are in a balanced state of relaxation. It therefore follows that the depressor muscles are also fatigued and relaxed and it may be logically concluded that the mandible has assumed a true physiologic rest position. When the depressor muscles have been fully relaxed, the mandible will maintain this rest position for an indefinite length of time and measurements recording this position can be made repeatedly and will be constant.

In this procedure, calibrated measurements are used to determine the physiologic rest position and the occlusal or contact position of the mandible. Measurements may be made from any convenient point on the upper portion of the face to any point on the mandible. The points used are arbitrary, and are selected as convenient aids. The vertical dimension may be determined from the nasion to the mentum; from a point on the medial line of the frontal bone to the symphysis, or from a point on the nose to a point on the symphysis. In other words, the measurements may be effected from any convenient point on the mandible to any fixed point on the maxilla. I have found it most practical and convenient to utilize measurements made from a point on the nose to a point above the symphysis.

The measurements made refer to an anterior bite opening.

When the proper physiologic rest position of the mandible has been determined, and the proper vertical dimension established, a functional centric occlusion must be registered in the mouth.

Centric position has been defined as the most retruded position of the condyle in the glenoid fossa from which lateral movements can be made with comfort. Centric has been described as the beginning and end of all mandibular movements. Or, centric, as I see it, may be referred to as that position of the mandible in relation to the maxilla when the condyles are properly balanced in the glenoid fossa. It is generally agreed that the centric position is at the apex of the Gothic Arch Tracing,[9, 10] which is a recording of all movements of the mandible—lateral, protrusive and retrusive. Centric position is now understood to be the point to which the mandible returns after each successive mandibular movement.

Since the stresses and forces applied by the musculature are responsible for positioning the mandible at rest, as well as in function, a balance of the muscles must first be secured. However, until recently, the consideration that the muscles are the basic guiding factors for establishing centric position, as well as vertical dimension, was unknown. It was believed that a proper contact relation of the teeth would satisfy all requirements.

Therefore, when a centric is registered, utilizing the relationship of the teeth as a guide, the results may only satisfy the static requirements. A true centric position is a true functional centric relation of the mandible to the maxilla, when a balance of the muscles has been obtained.

One may obtain under static conditions, therefore, what appears to be a centric position without obtaining a true functional centric relation of the mandible. A static centric position is a position of the mandible in relation to the maxilla when the occluding surfaces of the teeth are in contact. This position, however, will merely satisfy the aesthetic considerations. On the articulator, the case may appear quite satisfactory, with seemingly perfect occlusion and with proper cuspal interdigitation. Furthermore, in static occlusion in the mouth, the case may continue to appear satisfactory. However, when put to the test under functional or dynamic conditions, the results may be entirely different. In a mouth with natural dentition that has not been properly balanced the patient will, of course, manage to masticate food. However, even though the premature contacts or occlusal discrepancies are removed, the patient may have more ease in lateral excursions but the bite will continue to be off balance, and will not function with the maximum efficiency and comfort. The results will be discomfort during mastication, trauma and muscular pain, possible traumatic disturbances in the temporomandibular joint; and a compensating factor

for this proper lack of balance will result in loosening of the teeth, periodontal disturbances, and a general breakdown and degenerate process of the alveolar bone. In an edentulous mouth, the result of an improperly balanced centric occlusion may manifest itself in displacement of the dentures, discomfort and inability to masticate, trauma, muscular soreness, gum irritation and speech and phonetic defects.

There are two different schools of thought on the proper procedure to follow in obtaining an accurate centric position. One group advocates registering a functional centric position under conditions where pressure is applied. The explanation for this reasoning rests on the sound theory that during the process of mastication, the muscles are unquestionably under a semblance of stress. Another opposing group maintains that a centric registration, taken under pressure, might cause a displacement of tissue and so will result in an inaccurate and distorted registration.

After studying all phases of this vital problem, theoretically and clinically, and analyzing and experimenting with the scientific procedures and aspects, I have determined that the most accurate method, and the one that comes closest to approaching the physiologic balance of the stresses and forces exerted by the muscles, is the application of a light pressure to register a proper functional centric position. The application of a light pressure, I have concluded, is the most precise and accurate technique for simulating and imitating the resiliency of the tissues and muscles functioning in the oral cavity. The introduction of a rubber cushion of varying and graduated degrees of resiliency, while certainly not the perfect solution, is probably the most reliable procedure at our disposal today. (Fig. 7.) While many other techniques have employed a pressure device, such as a spring instrument or a metal platform making contact with another metal platform,[11] they differ mainly because of the application of stress against a non-pliant and unyielding substance such as metal. Since the mouth, or any part of the body is controlled by the musculature, it cannot be expected to react accurately to a static device which disregards the resiliency that is necessarily present in a living body. In reproducing a balance of muscles, it is imperative that this resiliency be approximated as closely as possible.

Please note that emphasis is placed on the application of a *light* pressure. Utilization of a light semblance of pressure is desired to properly equalize and balance the forces always present. If a rigid or unyielding pressure is exerted there will undoubtedly be an unnatural displacement of tissue and forces, since it is not normal for the mandible to exert force against an object that does not give or is unbending. Some slight displacement of tissue, on the other hand, is natural and normal when any form of pressure is applied. For example, any foreign object placed in the mouth, such as a bite rim, a mechanical device, or even food or the tongue itself, will cause some displacement. However, when slight displacement is caused by food or the tongue, there is a compensating factor in the resiliency and elasticity of the muscles and tissues. But, when undue pressure is exerted, the displacement is so great as to give distortion and will result in an incorrect and inaccurate recording. In this case, the muscles will be strained and sore, and they cannot be properly balanced because proper resiliency has not been applied with the proper amount of light stress required, so that the result will be a forced centric position.

From these considerations, it can be readily observed that if a centric registration is made at the physiologic rest position, and when a proper balance of the muscles has been obtained, the related intra-oral factors, such as the teeth and their cusps, will nearly always become balanced when occluded.

Illustrative of the preceding principles and techniques is the following history of a practical case of complete rehabilitation of the mouth.

Case History: Mrs. S.

Short overbite with extensive attrition.

The coronal portions of the teeth were short, meeting in a slight overbite, and were

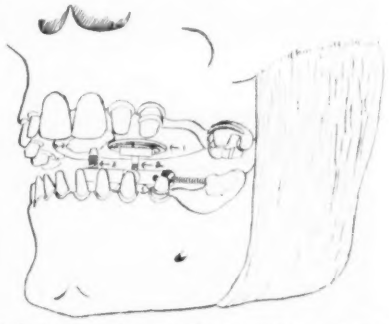

Fig. 7.—Instrument employed to register a functional centric position.

1. Resilient rubber cushion that simulates the biting pressure exerted by the muscles during function.
2. Central bearing platform.
3. Anterior vertical pin that maintains the predetermined vertical dimension by making a positive contact with the opposing metal platform.
4. Metal platform to maintain positive contact of intra-oral marker.

further reduced in size by extensive attritional wear. Lack of mandibular support, coupled with the continued attrition, resulted in a closure of the bite with a loss of 5 mm. of vertical dimension. (Figs. 8-10.)

The patient was a woman, thirty-eight years of age. The oral hygiene was poor with a generalized gingival inflammation and heavy deposits of calculus, resulting in a recession of the gingiva. The patient was a vegetarian and it is feasible that the lack of proper stimulation during mastication was a contributing factor in the condition of the gingiva.

There was a slight diastema of the maxillary anterior teeth, with mobility of several teeth during lateral excursion as a result of

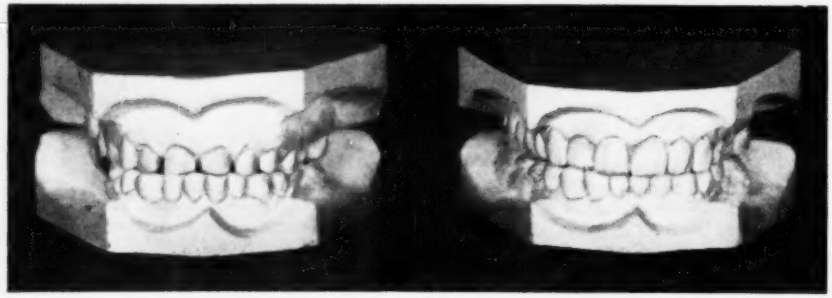

Fig. 8.—Casts of bite before and after treatment, showing correction of bite and diastemata.

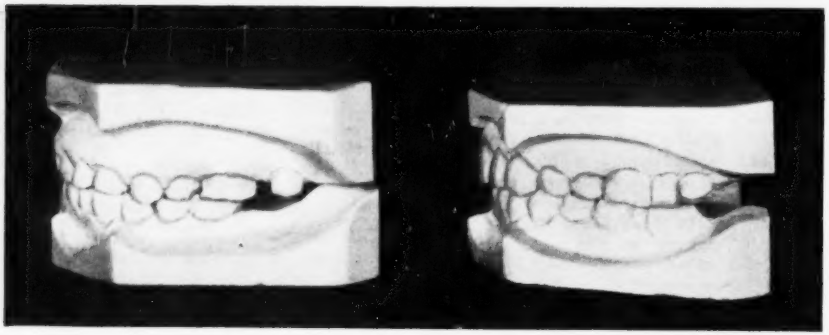

Fig. 9.—Left side view of casts before and after treatment.

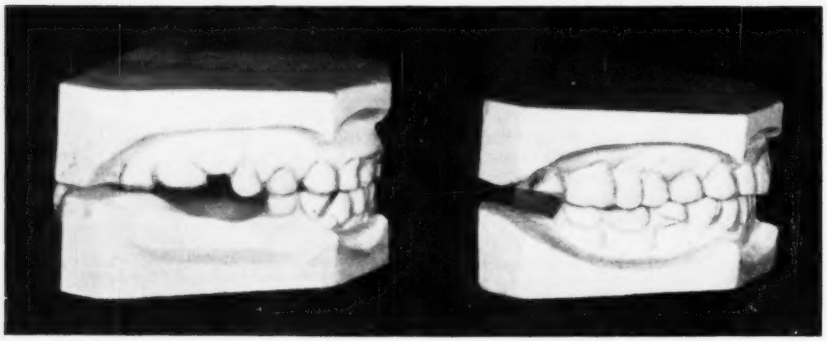

Fig. 10.—Right side view of casts before and after treatment.

traumatic occlusion. Undue strain was undoubtedly placed on the anterior segment due to a lack of mandibular support. (Fig. 11.)

The mandibular first, second and third molar teeth on the right side were missing, as well as the left second and third molar teeth. The lower right cuspid was crowded and rotated mesially.

On the maxillary right side, the first molar was missing, causing the second molar to drift mesially and leaving a narrow interproximal space between the second bicuspid and second molar. On the upper left, the first molar was missing and the second molar had drifted mesially in place of the first molar, leaving an interproximal spacing between the second and third molars. The mandibular right second bicuspid, as well as the maxillary left second bicuspid teeth were devitalized.

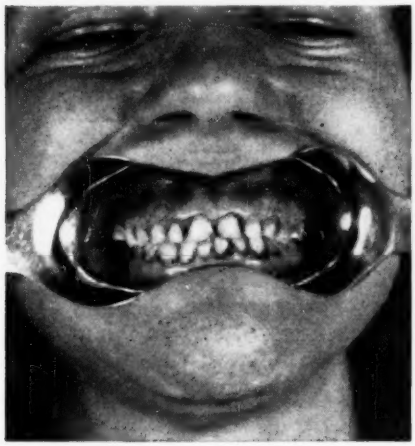

Fig. 11.—Close-up showing original condition of bite before treatment.

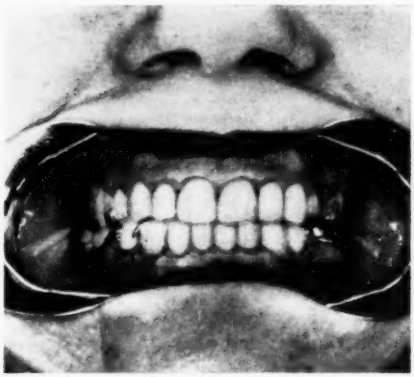

Fig. 12.—Front view of completed restorative work, with an increase of 5 mm. in lost vertical dimension.

There was a noticeable amount of alveolar resorption between the maxillary first and second bicuspid teeth, and the second bicuspid and first molar on the left side, resulting in a deep pocket formation.

There were a number of overhanging fillings with poor interproximal contact and most of the fillings were undermined with decay.

In general, the mouth was in a badly mutilated condition.

Treatment of this case by occlusal equilibration was contraindicated. This method of treatment would further reduce the length of the teeth, as well as oversensitize them. When a bite is equilibrated by means of grinding and balancing the cusps, this treatment must be continued indefinitely.

Preliminary measurements before any operative work was started were taken to determine the exact amount of vertical dimension that had been lost.

The mandible at its physiological rest position measured	64½ mm.
The mandible in functional occlusion measured	57 mm.
Total amount of freeway space before treatment	7½ mm.

A total of 7½ mm. of freeway space or of actual working space existed in the mouth before treatment.

In rehabilitating this mouth, it was possible to reclaim 5 mm. of freeway space leaving 2½ mm. freeway space for function.

In treating this case conservative prophylactic therapy was used to remove the deposits of calculus and to curette the periodontal pockets. A gingivectomy was performed on the posterior teeth to clean the infected areas and the pocket formations.

Porcelain jacket crowns were built on the maxillary and mandibular teeth from the first bicuspid across to the second bicuspid. (Fig. 12.)

Pontic bridges were constructed to supply the missing molar teeth on the upper left and right sides. Gold onlays were constructed on the remaining posterior teeth on the maxilla.

A lingual bar chrome case was utilized to supply the missing mandibular teeth.

This case has now been in the mouth over two years with very satisfactory results. Figures 13, 14, 15 and 16 illustrate front and profile views of the patient before and after treatment.

SUMMARY.

Advances in the field of complete mouth rehabilitation have been made slowly through a period of trial and error, and have been further hampered by a reluctance on the part of the profession to accept this all important phase of dentistry. This scepticism has resulted from the failures of pioneers who made futile attempts to raise bites indiscriminately.

Gradually, however, with the general advancement of all sciences through intensive research, there evolved a realization that in the physiology of the muscles, in the mechanics of mastication, as well as in all the sciences, are the basic and fundamental principles underlying a working knowledge of the masticatory apparatus.

From these theories and principles there came about a practical knowledge of the

Fig. 13.—Front view of patient before treatment.

Fig. 15.—Right profile of patient before treatment.

Fig. 14.—Front view of patient after treatment.

Fig. 16.—Right profile of patient after treatment.

existence of a physiologic rest position and its relation to the intermaxillary freeway space, and vertical height of the face. As a result of these findings, a functional centric position was established as a means of balancing the forces and stresses present in the mouth. Finally, the procedure from this stage became a purely mechanical one, with the basic sciences and theories as guides.

Boston, Mass.

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The Present Conception of the Aetiology and Histopathology of Dental Caries*

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At the present time there are three separate theories concerning the aetiology of dental caries, and not one of them offers an entirely satisfactory explanation of the carious lesion. Each theory has its proponents, and each has as many opponents. Consequently, the subject has become highly controversial, with the result that the general practitioner has been left in a state of bewildered confusion. In an endeavour to clarify the present position, it is proposed to sift the evidence which comes within the scope of this paper, and to correlate the data obtained, so that a lucid picture of the progress of the carious lesion can be presented to the dental practitioner.

The three theories referred to are:

1. Structural theory.
2. Acid decalcification theory.
3. Proteolytic invasion theory.

Each of these theories will be subjected to a critical survey, and then we will endeavour to sort out and assemble the proven facts and apply them, together with some additional knowledge, to an interpretation of the histopathology of the carious lesion.

1. Structural Theory.

The first of these theories is not the oldest, as it came into being as a result of a series of animal experiments, and human investigations, conducted by the English research worker, Lady May Mellanby, in the years

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1929-1934. Before that time Miller's well-known chemico-parasitic theory of caries was generally accepted as giving a satisfactory explanation of the clinical manifestations of caries, and, indeed, our conservative operative technique, as practiced today, is based on Miller's conception of the carious process. However, it soon became evident that there were occasional inexplicable exceptions to the Miller theory in clinical practice. Dentists were frequently confronted with cases of elderly people who retained excellent dentitions despite the fact that their dietaries were unrestricted, and that they paid little or no attention to oral hygiene. These fortunate people invariably attributed their immunity to dental caries to the fact that they and their forebears had always possessed "good strong teeth." This belief—that well-calcified teeth are able to present an active resistance to dental decay—was, and still is, firmly embedded in the public mind. Outbreaks of caries during pregnancy and lactation are still regarded by many as the indirect result of weakened tooth structure, brought about by a transition of calcium from the mother's teeth to supply the needs of the developing offspring. Nowadays, it is known that once enamel is formed it remains fixed, and that an extensive shift of calcium salts from the teeth to the system is a biological impossibility. The resorption of a calcified tissue necessitates a close approximation of the tissue to the vascular system to permit osteoclastic activity, so that any calcium withdrawal from the teeth could only be effected from dentine, and not from enamel via the pulp. Despite this fact, it has been proved very difficult to change popular belief, because, to the layman, popular beliefs and personal opinions often carry more weight than conclusions based on scientific facts. Consequently, when Lady Mellanby first published the results of her experiments, in which she had been able to produce poorly calcified teeth in animals who were fed on diets deficient in Vitamin D, it merely confirmed a belief already widely held. When later she published the results of her investigations in 1934, on three groups of children, it was thought that the riddle of dental caries had been solved. Her final conclusion, as a result of this work, was:

> that a relatively high Vitamin D content of the food can do much to diminish the incidence of caries, if the vitamin is given during the development of the teeth; that a beneficial effect may be obtained if the vitamin is given at a fairly late stage of development and that, even when given after the eruption of the teeth, the onset and spread of caries is delayed.[1]

In an earlier paper[2] it has been shown that the methods used to establish the caries incidence in this investigation were so inaccurate as to render the statistical analysis of the results useless and also that the figures obtained did not warrant the rather confident conclusion. It is unfortunate that Lady Mellanby employed another misleading method to determine the degree of so-called hypoplasias. This was obtained by allotting a scale of points according to the degree of hypoplasias determined as

> a result of testing the roughness of the enamel of the buccal surface with a fairly sharp probe, also taking into account the presence of opaque patches, general external appearance, peculiarities of colour, etc.[2]

In fairness to Lady Mellanby, it should be pointed out that she does not possess dental qualifications, otherwise she could not have made the mistake of believing that tooth structure could be accurately gauged by this method. Figure 1 graphically illustrates the difference between the pitted and stained enamel on that portion of the crown exposed to the destructive actions of the mouth, and the smooth, well-formed enamel on that part of the crown which has been protected by the epithelial attachment.

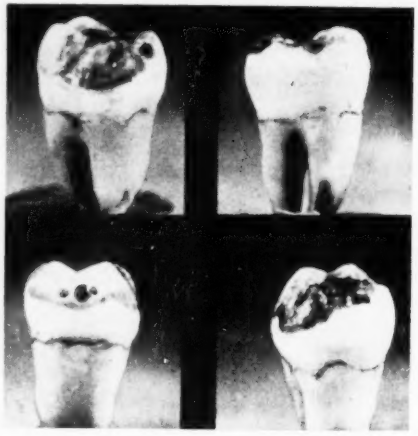

Fig. 1.—Molar tooth, illustrating the futility of attempting to classify the structure of the enamel by the Mellanby method of "testing" the surfaces exposed to the oral cavity with a sharp probe. Note the difference in enamel "texture" lying below the epithelial attachment.

So much for the methods employed in this large-scale investigation, upon which the structural theory is based. The theory has since been reiterated so often that most medical men, and many dentists, have now come to regard it as an accepted fact. It should be noted, however, that in this investigation no indication was given as to how the enamel of a tooth, having no active circulation, and therefore having no active defence, either to acids or bacterial attack, could resist an attack on its external surface.

If the more recently proposed proteolytic invasion theory is correct, then a tooth with enamel containing more organic material would be more vulnerable to proteolytic attack. But no one has yet provided the necessary experimental evidence to prove that these organic pathways can be entirely obliterated by adding any amount of calcium and Vitamin D supplements to the diet. In any case, the organic matrix of the dentine and the enamel is a normal component of tooth structure, so that it seems neither likely, nor desirable, that they could be eliminated.

The Mellanby investigations can be wholly dismissed as evidence that dental caries could be prevented by nutritional means of improving tooth structure but there have been a number of other investigations which *do* provide answers to questions relating to tooth structure and dental caries. These questions concerning the relationship of nutrition to developing tooth structure during the pre- and post-natal periods have been dealt with in another paper which I have presented earlier.[3]

After twenty years of clinical trial, during which it has become common practice to administer calcium supplements to mothers during the period of pregnancy, dental caries is still very much with us. This disappointing outcome has resulted in a swing away from attempts to control dental caries by systemic means, and attention has once again been focussed on the external environmental causative factors. The old acid decalcification theory of Miller's has returned, but it now appears reclothed in more elaborate raiment. It was only natural that the external factors should receive more intensive investigation, because there is now sufficient evidence—clinical, radiological and histological—for us to be able to make the positive statement that caries commences on the *external* enamel surface.

2. Acid Decalcification Theory.

The fact that partial dentures, flat surfaced denture clasps, or any other mechanical appliance which tends to hold stagnating food debris in close approximation to the tooth also tends to initiate the carious lesion indicates that it is a problem of food decomposition in the immediate external environment of the tooth. The foods which we eat consist of carbohydrates, proteins and fats and, of these foods, only carbohydrates and proteins are subject to digestive changes in the mouth. Proteins, if left for a period in stagnation areas, are subject to putrefactive changes. This change occurs when protein debris such as meat fibres becomes wedged between contact points or collects in deep approximal pockets. The debris will undergo proteolytic dissolution by bacterial enzymes, and the resultant putrefaction produces the characteristic foetid odour associated with pocket formation in the mouth. The end products of this type of decomposition are alkaline. Thus, the calcified dental tissues are *not* involved with this type of reaction, but the condition *is* associated with disease of the soft periodontal tissues. On the other hand, the cooked starches and the sugars are capable of undergoing enzymic changes in the mouth. The cooked starches, or polysaccharides, are first of all converted by pytalin to the disaccharide maltose. The disaccharides, including cane sugar, are then converted by invertase to the monosaccharide glucose.

It has now been definitely established that glucose undergoes a relatively rapid fermentation process in the mouth. This fact has an important clinical application, because glucose also possesses a very high caries potential among the commonly eaten sugars. The chemical mechanism of this fermentation process was discovered during the period 1930-1931 by research workers in fermentation industries and by those studying carbohydrate metabolism in muscle, brain and heart tissue. But it was Fosdick[4] who showed that the same intermediary reactions which are involved in the conversion of glucose to lactic acid by enzymes in these tissues can be accomplished in the mouth. The actual conversion requires a number of intermediate reactions, each one requiring a specific enzyme or co-enzyme. Most of these enzymes are furnished by mouth organisms. These reactions involve a production of hexose monophosphoric acid, hexose diphosphoric acid, phosphoglyceric acid, glycerophosphoric acid, pyruvic acid and lactic acid. There does not seem to be any doubt that, when this reaction takes place within the dental plaque, the resultant temporary concentration of these acids upon the external surface of the enamel in some way initiates the carious lesion. Kesel[5] has backed up this statement with six different sets of evidence.

(a) *Clinical evidence.*

Clinically, caries appears to be limited to those areas on the teeth which, by reason of their contour or position, favour the retention and stagnation of carbohydrate material.

Carbohydrates are the only kinds of foodstuffs which can be converted in the mouth into acid of sufficient strength to destroy enamel.[5]

(b) *Histological evidence.*

Kronfeld[6] has noted a similarity between microscopical appearances of hard ground sections of early approximal caries and those of intact enamel exposed to the action of dilute acids. There seems no doubt that the

first step in caries of the dentine consists of an acid dissolution of the inorganic salts, because every practising dentist must have lifted up layers of gelatinous dentine from the floor of a cavity and noted the absence of calcified material. It is the persistence of the organic matrix that allows the dentine to retain its form and shape.

(c) *Nutritional evidence.*

So many people have noted the relationship between the incidence of caries and refined carbohydrate intake, that it seems superfluous to review the evidence on this aspect of the subject. It is significant that, although one is occasionally confronted with an exceptional case of caries immunity despite a relatively high intake of sweets, no one has yet demonstrated caries occurring without fermentable carbohydrates being included in the diet. Primitive Eskimos, living on a high protein diet, mostly the products of hunting, are normally caries free, yet Waugh[7] was able to initiate caries in six weeks by giving Eskimo children a liberal allowance of candy bars during this period.

(d) *Chemical evidence.*

Stephan,[8] determining the hydrogen ion concentration on the tooth surface by means of a small antimony electrode, has measured the degree of acid formation in the mouth. He has shown that acid formation of a pH sufficient to decalcify enamel takes place within a few minutes after a rinse with glucose or dextrose.

Furthermore, the rate of acid production is proportional to the degree of caries activity. Conversely, Dreizen[9] has shown that resistance to caries is directly related to the buffering potentiality of the saliva and its ability to neutralise acids.

(e) *Bacteriological evidence.*

A constant relationship between the acidogenic or acid-forming organisms and the aciduric or acid-tolerant organisms and carious lesions has been shown by research bacteriologists over the last fifty years. The reduction of these organisms in the oral flora, by a severely restricted carbohydrate intake, is the basis of caries control as practised by Jay[10] at Michigan.

(f) *Control of caries by various preventive measures.*

Most of these measures are based on:—

(i) Changing the composition of the external layer of enamel to render it more resistant to acid attack.

(ii) Using enzyme inhibitors to prevent the formation of acids in proximity to the teeth.

On the face of it, this would seem to furnish sufficient evidence to support the acid decalcification theory to the exclusion of all others. However, a further examination of the problem will reveal that dental caries is a far more complicated problem than simple acid decalcification. The evidence advanced so far only enables us to say that there is no doubt that caries begins on the external surface of the enamel and that an acid fermentation within the dental plaque is the major factor concerned in the primary attack. When we come to apply the acid decalcification theory to the mechanism or progress of the carious lesion through the enamel and the dentine, then we have to confess that at the present time this theory does not provide a satisfactory answer to the histopathology of the carious lesion. As a matter of fact, none of the theories advanced at the present time provide a satisfactory interpretation of the carious mechanism. This is rather strange, because histological evidence has established a definite pattern to which the lesion conforms in its progress through the hard dental tissues, so that interpretation might seem to be a relatively simple matter. The difficulties arise from the fact that both enamel and dentine consist of varying amounts of hard, inorganic material and soft, organic tissue, and the respective actions which are ordinarily responsible for their dissolution were thought to be opposed to one another. For instance, acids are responsible for the decalcification of the inorganic material, whilst the bacterial putrefaction of organic material, which is protein in nature, results in a local alkalosis. Thus, the respective actions appear as incompatible as the proponents of each opposing theory. As will be seen later, another obstacle to interpretation is the technical difficulty involved in the preparation and simultaneous preservation of hard and soft tissues when preparing them for histological section.

Before proceeding further, it will be necessary to note the shortcomings of both acid decalcification and proteolytic invasion theories, when applied to the interpretation of the histopathology of the carious lesion.

The acid decalcification theorists believe that:—

(i) Acids are produced within the dental plaque as a result of the enzymic degradation of fermentable carbohydrates contained in solution therein.

(ii) These acids become concentrated deep under the plaque, where they are protected from the buffering action of the saliva.

(iii) When the concentration of acids reaches a pH below 5, the enamel is decalcified. These minute attacks are repeated every time concentrated carbohydrates gain access to the plaque.

(iv) These repeated attacks by acids on the enamel underlying the plaque finally reach the dentine, which is first of all subjected to a preliminary decalcification and finally subject to proteolytic dissolution by bacterial enzymes.

This theory satisfies the general clinical, histopathological and bacteriological picture of the lesion in most respects, but it does not explain:—

(a) Why acids, when introduced into the mouth in sufficient strength to decalcify enamel, do not cause caries; instead they cause the simple chemical dissolution of enamel known as erosion, e.g., lemon juice or dilute HCl used medicinally.

(b) Why it is not possible to produce a typical carious lesion experimentally, when a small window in a wax covered tooth is exposed to acid action. In such cases the action of the acid results in an *extensive* cupping out of the enamel and comparatively *little* destruction of the dentine, where the action is much slower.

(c) If acid action alone is responsible for the carious process, why the lesion is in the enamel relatively small, compared to the dentine, when enamel containing approximately 95% inorganic material should be more vulnerable to acid action than dentine which contains only 70%.

(d) Why enamel forms a limiting boundary to the attack, once the lesion is established in dentine. For example, a cavity which commences on one surface of a tooth does not burrow through and emerge on another surface. It may, of course, become confluent with another externally produced lesion.

(e) The acid decalcification theory denies proteolytic action in the enamel, but recognises it as the final stage in the dissolution of the dentine. This is a particularly weak point in this theory, because bacterial access to the dentine must take place via the enamel in the stages before the cavity presents a macroscopic opening to the mouth.

Because the acid decalcification theory fails to find satisfactory answers to these questions, an entirely different conception of the carious process has been postulated by those who adhere to the proteolytic invasion theory.

3. Proteolytic Invasion Theory.

This theory holds that:—

(i) Caries is primarily the result of a proteolytic invasion of the organic pathways in the enamel.

(ii) This action destroys the organic matrix of the enamel by bacterial action and thus frees the inorganic material from its organic bond.

(iii) The exposed inorganic material in the enamel rods is then subject to acid dissolution, but this is regarded as a secondary process.

Caries of the enamel is thus visualised as a two-phase process, acid alone not being considered responsible. This seems a logical viewpoint, because both organic and inorganic tissues are present in enamel, and it should therefore require a two-phase process for its dissolution. We recognise a similar double-phase process in dentine, but in this case it would seem that acid decalcification is the primary factor. Thus it is hard to believe that the action should start in one direction in the enamel and go into reverse when it reaches the dentine. This poser cannot be explained by Gottlieb,[11] one of the main exponents of the proteolytic invasion theory, for he says:

> The acid forms often a spearhead in dentine caries, but no explanation for this fact is available.

If proteolysis of the organic material is the primary factor in producing enamel caries, then it should also be the primary factor in caries of the dentine, because the latter contains a much larger percentage of organic material.

There are other objections to this theory. The main one is that it does not explain the indisputable clinical fact that the lesion is undoubtedly initiated by the localised fermentation of carbohydrates to acids. High protein diets do not predispose to caries; rather do they tend to confer an immunity.

At this stage we would seem to have reached a deadlock were it not for the fact that some recent research on protein hydrolysis might yet provide a complete solution to this age-old problem which has baffled many of the world's best research workers for the last fifty years. This work has been performed by Atkinson.[12] It must now be obvious that the mechanism of the carious process involves the dissolution of both organic and inorganic material in an acid medium. We know of at least one proteolytic bacterial enzyme which acts in an acid medium, and that is pepsin, which acts in the presence of dilute hydrochloric acid in the gastric tract. Under these conditions, proteins are broken down into

their respective amino-acids. By means of partition chromatography, Atkinson has shown that the dentinal protein contains eighteen amino-acids. Atkinson reports:

> that water extracts of sound dentine failed to reveal the presence of any free amino-acids, while water extracts of carious dentine contained free aspartic acid and glutamic acid. Further experiments revealed that aqueous solutions of aspartic and glutamic acids were capable of decalcifying the enamel and dentine of the tooth.[12]

With this key piece of information, it now becomes possible to correlate the knowledge obtained from both schools of thought and to present a descriptive interpretation of the carious lesion which conforms both to clinical facts and the known histopathological data.

The Dental Plaque.

Wherever the enamel surface presents a natural stagnation area (viz., grooves, pits, fissures, contact points) or an artificial stagnation area (e.g., a fold in the buccal mucous membrane lying against the buccal surfaces of the posterior molars), a pad of filamentous, thread-like organisms attach themselves to this surface. Although these organisms are very tenacious, Gottlieb[13] claims that they can only gain attachment to the enamel by invading an exposed lamella. If this statement is correct, then it would explain why caries sometimes occurs in a non-stagnation area, such as the crest of a cusp. Unless detached, this fibrillar, gelatinous network becomes a catchment area for food debris and other types of oral bacteria, until a dense, felt-like pad of material is built up. The plaque now becomes a miniature micro-universe, consisting of *Leptotricia*, *Streptococci*, *Staphylococci*, diphtheroids, *Lactobacilli*, yeasts, and many other forms. The bacterial population in the plaque is dependent on the type of food which we eat. The proteolytic types of bacteria produce enzymes which are capable of de-aminising the amino-acids, to produce ammonia. This action would have a buffering effect in the plaque, and inhibit the growth of the acid-producing types of bacteria. When excessive amounts of readily diffusible carbohydrates are eaten, this balance is destroyed and acid-forming and acid-tolerant bacteria predominate. In addition to the organisms in the plaque, it contains precipitated mucin, or protein material from the saliva, and a certain amount of soft food debris. The consistency of the plaque varies from the white, pultaceous material known as *materia alba*, which is often noted around the buccal surfaces of the posterior teeth, to the tougher, denser types formed at contact points. Most types of food have access to the plaque, but strong sugar solutions which may develop an osmotic pressure of 40-50 atmospheres probably have the greatest access. On the same basis, thick, ropy types of saliva probably have very little access.

All types of plaques have a considerable buffering capacity, that of *materia alba* being exceptionally good. Fosdick[14] explains that when weak sugar solutions are allowed to diffuse into the plaque, lactic acid is formed but the buffering action is sufficient to prevent active decalcification taking place. Apparently the lactic acid is developed on the *surface* of the plaque, where it is neutralised by the saliva or by the plaque itself. Under these conditions plaques may actually exert a protective effect. When stronger solutions of sugar are used, say 50%, the tremendous osmotic pressure developed draws the solution deep into the plaque and into the exposed lamellae in the teeth. At the same time, water is withdrawn from the plaque. Under these conditions the sugars are converted into acids, which are held directly in contact with the enamel surface, and the buffering capacity of the plaque is broken. When pultaceous, starchy food debris collects around the teeth the degradation process to acids is much slower but the sticky nature of such food debris compensates for the slower action by holding them against the tooth surface for a much longer period. It is most important that we realise the full significance of this reaction. It is this concentration of acids on the tooth surface which sets the carious process alight. What happens next is deeply interesting to dental pathologists, but it plays a relatively minor role in the prevention of dental caries as it bears no relation to the removal of the causative factors.

The Structure of the Enamel Surface.

The enamel surface of newly erupted teeth is covered by a protective horny cuticle. Underneath but separated from the surface by the primary cuticle lies a honeycomb structure consisting of the hexagon-shaped ends of the enamel rods, which are held together with intercementing substance. Each rod consists of an organic central core, into which are deposited during the maturation process masses of hydroxyapatite crystals. Viewed under the electron microscope, each enamel rod reveals itself as composed of crystals of this material, which are tightly packed in the core of the rod. Each rod contains about 20 crystals measured across the usual external diameter. The rods are each enclosed in an organic sheath, and they are separated by inter-rod cementing substance which contains the same ionic crystals but having a wider spacing due to the greater content of organic matrix.

Interspersed between the rods lie lamellae, which are tracts filled with organic material. It had been thought that these lamellae might be cracks formed in the process of sectioning, but this theory must be discounted because they are lined or filled with organic material. Previously it had been thought that each enamel rod was formed by a separate ameloblast, as it made its way from the dentino-enamel junction to the enamel surface. Gottlieb[13] ridicules this theory by pointing out that it does not explain how the same number of rods could arise from the relatively small dentinal surface and form the much larger external enamel surface, unless they bifurcated or grew much larger. He says that there is no histological evidence of either taking place. It is also impossible to believe that one ameloblast could change its position and course to the extent of producing the twisted and gnarled enamel seen under the cusps of the teeth. Gottlieb believes that the function of the ameloblasts is to lay down a fibrillar organic matrix. This matrix is subjected to a mass calcification which is first laid down as homogeneous material. Finally, the prisms emerge from this mass in much the same way as crystals emerge from a solution, leaving the organic material as the prism or rod sheaths. During this process some tracts may fail to maturate completely, leaving lamellae or tracts composed of uncalcified organic material within the enamel of the tooth. During calcification the replacement of water and protein by calcium deposition produces internal tensions and consequent shrinking of the matrix which results in lamellae or cracks running to the external surface. Gottlieb says that during the process of eruption the tissues surrounding the teeth invade these lamellae but, following eruption, the enclosed tissue becomes severed and this leaves a tract filled with necrotic tissue which later provides a nidus for subsequent invasion. However, irrespective of the nature of their formation, lamellae do occur in histological sections of enamel and their significance must be considered when studying the method of the carious invasion of enamel.

So now we have acids concentrated under the dental plaque in close approximation to a tissue, consisting of inorganic material composed of hydroxyapatite crystals and organic material in the shape of the rod matrix, the rod sheaths, and the lamellae. What happens next is, of course, the basis of the present day controversies. Interpretation of the lesion has been rendered difficult because of the difficulties encountered in the preparation of calcified tissues for histological section. If these tissues are subjected to a preliminary decalcification by acids so that sections can be cut by a microtone, then details of the enamel structure are lost and the pathological processes cannot be studied. If hard ground sections are made to preserve the histological details of the hard tissues, then it is not possible to study the organic matrix or invading organisms by this method. Credit must be given to Frisbie, Nuckolls and Saunders[15] for developing a technique to overcome this difficulty. They employ a *selective* method of decalcification which involves a preliminary fixation of the enamel matrix, thus rendering it less soluble to the action of acids used for decalcification. As a result of their study of sections prepared by this method, they state:

> that caries of the enamel is a far more complicated problem than simple decalcification and removal of the inorganic salts.[15]

They claim:

> that whilst acid action under the bacterial plaque may account for the penetration and dissolution of the external enamel cuticle the deeper penetration is the result of an invasion by gram-positive spheroidal-shaped bacteria along the enamel rods, or in the spaces between the rods.[15]

There have been a number of recent investigations by research workers concerning the degradation of the organic contents of both enamel and dentine. Those conducted by Pincus,[16], Evans and Prophet,[17] and Atkinson[18] have produced results that may be correlated to give us a better understanding of this problem.

Pincus[16] assumes that the main agent in the production of the carious lesion is the enzyme sulphatase, which originates in certain gram-negative bacilli. This enzyme is able to release sulphuric acid from the appropriate components of the mucoproteins of enamel and dentine.

Evans and Prophet,[17] on the other hand, show that, *subsequent to mild decalcification*, the residual protein of dentine becomes susceptible to attack by proteolytic enzymes such as those produced by *Clostridia*, particularly *Clostridia histolyticum*.

It is of some importance to note that in both of these investigations the actions of the bacterial enzymes were ineffective against sound enamel and dentine. This fact indicates that a primary action is necessary, presumably of an acid nature, before these tissues can be subject to enzymic attack.

The contribution of Atkinson[12] relevant to the present discussion is that carious dentine contains free amino-acids in contrast to the normal dentine of sound teeth and that these amino-acids appear to be restricted to the dicarboxylic types, namely, glutamic and aspartic acids. This is claimed by Atkinson to be

evidence in support of the proteolytic theory, although his work was specifically confined to actions taking place in the dentine. Moreover, proteolytic enzymes might be expected to yield a greater range of free amino-acids than the two mentioned.

The view that lactic acid is the factor that initiates the carious lesion would not be inconsistent with the conclusions reached by the abovementioned workers.

Partridge and Davis[18] have noted that aspartic acid and, to a lesser extent, glutamic acid are split off from a range of proteins, including ovomucin and ovomucoid, by weak organic acids such as acetic or oxalic in a comparatively short time (2-8 hours) at 100°C., the proteins otherwise undergoing no extensive degradation. Experiments are now being conducted to ascertain whether at body temperature any such degradation of the enamel or dentine protein involving the release of the dicarboxylic amino-acids can be effected by lactic acid. If the results prove positive, even this mild modification of the protein matrices of the enamel and dentine might render them more readily susceptible to the subsequent action of bacterial enzymes as proposed by Pincus, Evans and Prophet, and other workers in this field. In this way a link would be forged between the proponents of the acid decalcification, proteolytic and sulphatase theories.

With the information that is now available, it is possible to present a hypothetical summary of the various stages involved in the progress of the carious lesion.

Summary.

1. Dental caries is primarily initiated by the enzymic degradation of fermentable carbohydrate material within the plaque.

2. The resultant concentration of organic acids within the plaque predisposes the enamel to a two-phase attack on its organic and inorganic constituents.

3. The attack involves a primary proteolytic degradation of the organic content of the surface enamel, but the manner in which this is accomplished is not yet understood. It is apparent that a preliminary action is necessary, presumably of an acid nature, because it has not yet been demonstrated that sound enamel is subject to direct attack by proteolytic bacterial enzymes.

4. The first step is a dissolution of the protective enamel cuticle, which exposes the organic pathways and the calcified material to attack.

5. Protein hydrolysis causes a dissolution of the rod sheaths and frees the hydroxyapatite crystals within the rods and inter-rod matrix from their organic bond.

6. The inorganic material is then exposed to a secondary acid decalcification.

7. The relatively small amount of organic material in the enamel limits the degree of destruction in this tissue, the lesion proceeding as a small finger-like projection to the dentino-enamel junction.

8. When lamellae are present, leading to the dentino-enamel junction, the progress of the lesion is more rapid and a greater amount of destruction takes place.

9. The proteolytic destruction of the enamel tufts at the dentino-enamel junction causes a separation of the dentinal matrix from the enamel matrix, and causes a lateral spread of the lesion at this function of the tissues.

10. Protein hydrolysis of the dentine releases the amino-acids, aspartic and glutamic, which cause a primary decalcification of the dentine.

11. The necrotic remains of the dentinal matrix undergo putrefaction by proteolytic bacterial enzymes derived from the oral cavity.

12. The resultant local alkalosis protects the inner walls of the enamel surrounding the lesion from further acid attack.

Finally, it must be emphasised that there is no longer any mystery about the *cause* of dental caries. We understand the nature of the causative mechanism and we know how caries could be prevented. Unfortunately, the obvious method of prevention, namely, the removal of the causative factors, is neither practicable nor acceptable to the sufferers from this disease, because it involves a radical change in the conventional dietary and in the commercial preparation of our staple carbohydrate foods. The real problem now confronting research workers is to find alternative methods of prevention which do not involve drastic changes of dietary habits and which do not clash with large-scale commercial interests.

Acknowledgments.

No originality is claimed by the author for any of the material used in the compilation of this paper. His task was to sift the scientific evidence produced by a number of world recognised research workers and to correlate it in an endeavour to explain what was previously thought to be inexplicable. Finally, the author wishes to record his appreciation of the invaluable assistance and advice rendered by Professor Trikojus, of the Department of Biochemistry, University of Melbourne, in the preparation of this paper.

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The Cast Base Crown—A New Technique Using the Indirect Method

*N. W. Kestel, M.D.S. (Syd.)**

The method of preparation for all crowns having a dowel or post† has been basically the same for many years. The root face is prepared in such a manner that it is divided into two planes: a small, steep labial plane and a less steep and usually larger lingual plane.

These planes run roughly parallel to the cemento-enamel line. The labial plane is set beneath the gingival while the lingual may finish above it.

Preparation is the primary factor in resistance to dislodgment, whilst the dowel is secondary. As the magnitude of overjet increases, the loading on the dowel increases, but with edge-to-edge relationship the loading is least.

The peripheral margin of the lingual surface should contain a bevel so that the dowel or post of the finished upper anterior crown, particularly in the overjet relationship, is prevented from acting as a lever to split the root mesiodistally. This would not apply to the edge-to-edge relationship; nor would it be significant in the case of a lower anterior where the stress applied would force the segments of the arch together, while stress applied to the lingual surfaces of the upper anterior teeth tends to force the segments of the arch apart, thus stressing the segments individually rather than collectively.

Technique.

A small box form, no larger than one-third of the area of the root face and similar in outline to its periphery, is prepared. In depth this box form should not exceed 2 mms. (Fig. 1.) In a young subject the box should be omitted if the orifice of the root canal is sufficiently large.

At this stage the foot of a used morse scaler point is cut off and the tapered shank reduced in length so that its taper approximates that of the canal and its length within the root is equal where possible to the length of the proposed crown. A morse scaler is suggested because it is already tapered and has a smooth surface and can be adapted for any size canal.

A copper band of suitable size is contoured to the root face periphery, before the root face is finalised.

Remove the excess length from the thick end of the point, allowing a projection of $\frac{1}{8}$ in. approximately into the free space. A retentive cut can be made into this part of what may now be called the root canal former. This cut is not necessary, as the taper provides adequate retention for the impression material.

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†This technique can also be used for constructing the gold core for a porcelain jacket crown restoration.

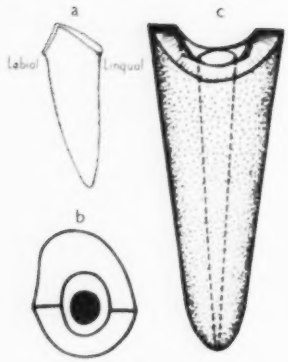


Fig. 1.—(a) Lateral view illustrating the inclines of labial and lingual surfaces of root face; (b) root face preparation showing box form; (c) labial aspect of root face.

To provide lubrication, if considered necessary, for the casting of the die, the canal portion of the canal former may be lightly smeared with vaseline or light oil.

Tracing stick composition is softened over a flame, the band filled and pressed over the root face in which the canal former is already in position. After chilling, the band is removed and the impression of the root face contained therein is examined for accuracy. The canal portion of the former is, of course, part of the impression at this stage.

With a large wheel stone grind a concavity into the labial face of the band. (Fig. 2.) This serves a dual purpose—identifying the position of the die and as a lock.

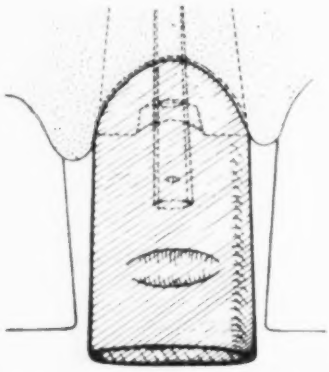


Fig. 2.—Copper band impression of root face showing band and post relationship.

The band is replaced on the root.

Check this stage thoroughly as the accuracy of all later stages depends on this. For preference use hydrocolloid and take a complete impression. The use of bridge trays should be discouraged for the arch as a whole should always be considered.

Remove the hydrocolloid impression and place in a humidor. The band impression is removed and placed aside until the shade of the tooth is determined. A temporary crown is then placed in position.

An impression of the other arch is taken and also placed in the humidor.

At this stage the thickness of the gold base on the labial plane may be determined by providing stops on this surface of the die. These will prevent the too often met hazard of having the wax pattern too thin in parts.

Two indentations are made between the impression of the box form and the periphery contained within the copper band with a number one round bur. The size of this bur is adequate but, should the holes be deeper than the actual bur head, the resulting stops on the die can be adjusted.

Obviously there will be corresponding holes in the finished casting but, as these are small and within the periphery, they are of no consequence.

Should the choice of die material be amalgam, then form a cylinder of several thicknesses of writing paper around the band and about twice its length, depending on the length of the canal former. Use sticky wax to prevent the paper unrolling. Push the band to the top of the cylinder and concentrate the amalgam on to the root face impression, then push the band down to the bottom of the cylinder and complete the packing of the die by grasping the cylinder and band firmly and striking it with considerable force on to the surface of the laboratory bench. Allow to set overnight. Should DIESTONE, DIOLITE or DUROC be preferred, make a cylinder of casting wax or thinned base plate wax. Paper must not be used unless it is impervious to moisture. The material of choice is then vibrated into the cylinder. Allow to set for at least one hour. MODEL KRYPTEX and similar materials may be used with a paper cylinder, but they are a little difficult to manipulate. It is best to form the cylinder first, but do not complete it. Have the cylinder formed about three-quarters circle; place the material on to the root face through the side, purposely putting in more than the space will contain; then continue the formation of the cylinder and sticky wax to secure it.

Whatever the die material, the containing medium is removed (Fig. 3) and a tapered root form is cut with coarse garnet discs producing six or more facets (Fig. 4). The copper band must be free from any die material. Before lubricating the die root, disc the lower peripheral edge of the copper band. This assures that no hydrocolloid will be flaked into the impression of the band while the band is being seated. (Fig. 5.)

Cast the model to the top of the die root, being careful to vibrate lightly. Cast the occluding model. With the hydrocolloid removed it remains now to push the die and band from the model. Hold the band end of the die in hot water till the impression compound with the band can be removed. The canal former will come away when grasped carefully with the Bernard pliers and rotated whilst being withdrawn. The die is replaced in its model which can be articulated with its occluding cast.

If the dowel crown be of the cast base type such as the cast base Davis, the modified Richmond or some types of plastic crown, the foregoing technique lends itself very well.

To obtain a casting of the post, base and the dowel of the porcelain crown or the extension to take a plastic crown, the author suggests a plastic form for the post or dowel to be used in the waxing up and as the sprue.

Measure off the length of the canal in the die and reduce it so that the end of the canal is exposed. (Fig. 6.) A piece of plastic either preformed or completely shaped is fitted to the die canal so that the end passes through the apex of the canal and continues with no taper for at least 4 mms. (Fig. 7.) The other end projects beyond the box form into the free space about 2 mms.—just enough to make retentive undercuts in this end, but short enough to allow the fitting of a porcelain dowel crown without too much grinding for its accommodation. Usually the enlarged

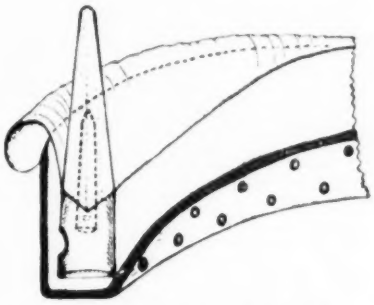


Fig. 5.—Band and die seated in hydrocolloid impression preparatory to pouring model.

entrance to the dowel hole in the crown accommodates it.

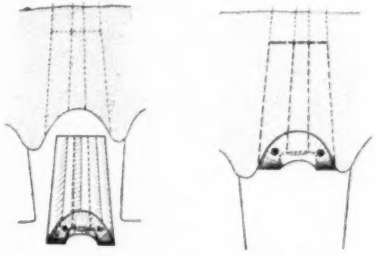
The crown is now adapted so that when it is held in position the labial facet of the root preparation is clear by the stops on the die face. The lingual surface of the crown is prepared to provide a metal support for this surface. (The Austinal crown has this as part of the crown design.) The root surface of the crown has labiolingual and mesiodistal grooves. These are cut with a diamond disc, but in cutting the labiolingual one, stop it short of the labial periphery. This is to avoid increasing the display of gold in that area. The function of these grooves is to provide stiffeners for the wax pattern and the casting where they may assist in the actual casting. All ground surfaces of the crown should be polished by garnet discs to facilitate removal of the wax pattern. (Fig. 8.)

Using hard inlay wax (KERR'S HARD), obtain a pattern of the dowel hole of the crown. Remove and then replace. A lower fusing wax (R. & R. MEDIUM HARD) is prepared into a disc the width of the root face and 3 to 4 mms. thick. This is made thoroughly workable

Fig. 3.

Fig. 4.

Fig. 3.—Impression and die before root form preparation.
Fig. 4.—Root form trimmed to produce tapering die.



(a) (b)

Fig. 6.—(a) Die after separation of band and trimming to expose end of root canal. Note stops on labial face of die; (b) die seated in model.

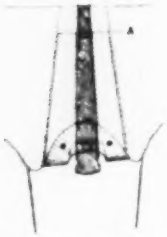


Fig. 7.—The plastic post fitted to the root canal and projecting into free space at the apex of the canal. The post also projects 2 mms. beyond the root face preparation.

while at the same time the exposed surface of the hard wax on the crown is puddled. With die and the plastic post form in position in the model, the soft wax is placed on the root face and the crown complete with hard wax dowel is forced into position. Whether the crown is in proper alignment or not, dismantle the crown from the wax and push the plastic post with base and dowel from the die, relubricate the various surfaces, and assemble. Prepare a bowl of hot water in which the fingers may remain without courting injury and hold the model complete with the assembly in the water for 15 seconds, then force the crown into its correct position. The hard wax forming the dowel is unaffected; the soft wax only yielding to the heat. Again dismantle, relubricate and assemble. (Fig. 9.) Finalise the margins. Prepare an inlay ring with asbestos liner. Place on wet, glossy paper. Mix and vacuum the investment if you have the means; if not, a careful technique will produce the result. Remove the crown and push out the pattern and place on the crucible former using the excess post to attach it. (Fig. 10.) The writer prefers to cut the crucible form when the investment has set. In any case carefully paint the pattern and remove any air bubbles or water globules by

Fig. 8.

Fig. 9.

Fig. 8.—Details of porcelain crown showing lingual preparation and mesiodistal and labiolingual grooves.

Fig. 9.—Diagram showing relationship between hard and soft wax, crown and post.

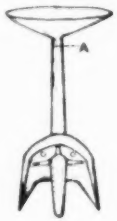


Fig. 10.—Diagrammatic representation of invested pattern showing the sprue, crucible form.

Fig. 11.—Diagram of completed casting. The sprue is sectioned at (A), which leaves the post equal in length to the root canal in the die.

sprinkling dry investment on the pattern and gently vibrating the sprue with a Le Cron Carver or like instrument. Fill up the ring and carefully feel the pattern into position. When ready remove crucible former, or in its absence cut down to the tip of the plastic post. Burn out and cast, using clean 5% platinised gold. (Fig. 11.) This method is very satisfactory and no casting in the writer's experience has failed. Let us examine the reasons.

Molten gold for casting purposes can be considered in the light of hydraulics, and in this case the gold is most fluid within the crucible form when the centrifugal force is applied; the pressure is greatest in the small orifice between the volume of gold and the cavity within the investment. Moreover, friction is less in the tapered sprue than in a parallel one of the same minimum diameter, and the taper provides a continuous reservoir and, should the button cause porosity, it will occur where it is of little consequence, that is at the tip of the post, and that is the

(a)

(b)

Fig. 12.—(a) Diagram of finished casting with crown fitted; (b) showing an actual crown and the die with stops on labial surface visible and corresponding areas in the casting.

reason why the writer does not use a crucible former as the excess 4.4 mms. are cut off in any case.

The casting is cleaned up, heat-treated, and boiled in acid to remove surface oxides. Figure 12 illustrates the completed crown and the die showing the labial steps.

Conclusion.

A method is described for the construction of a cast base crown by an indirect method having the following advantages:

1. The entire construction can be carried out in the laboratory.
2. The casting is homogeneous and has less chance of failure.
3. The angulation of the crown to the root canal is of no consequence.
4. No catalytic action between the molten gold to form the base and that of the dowel, as formerly.

T. & G. Building, Park Street, Sydney.

Acknowledgments.

The author wishes to acknowledge with appreciation the drawings by Miss N. Redfern and the photography by Mr. E. Slater, Clinical Photographer to the Faculty of Dentistry, University of Sydney.

The Application of Oral Screens to the Mechano-Therapy of Maxillary Protrusion*

A. Thornton Taylor, D.D.Sc. (Syd.)

Having for some time, and with heartening success, used oral screens either as a prelude to treatment or in the purely preventive capacities for which they were originally designed, I gained a profound respect for these appliances and for their obviously widening sphere of usefulness.

It became apparent that here was an appliance that served a manifold purpose in its application. It served as a means of harnessing the muscular powers of the lips, and of utilising the potentialities of pressure balances of the upper respiratory mechanism, and as well valuable reactions were developed among patients and parents who were quick to see obvious advantages from persistent use and co-operation with these appliances. The oral screen gathered momentum, as it were, in its usefulness, for where prominent incisors were retracted, lip closure became easier and more compressive power was developed for retraction. Also, and more potently, was the effect produced by the negation or counter-action of the abnormal muscular pressures of the lower lip so characteristic of Class II, Div. I, malocclusions, wherein the unnatural cushioning between the upper and lower incisors, protruding the former and retruding the latter, produces doubtless the most potent force for the fixation and progressive development of this type of malocclusion.

Clinical experience in the treatment of this type of deformity considered in relation to the beneficial effects of the oral screen, eliminating at one step the damaging pressures of the cushioning lower lip, led one to the thought that were this valuable mechanism applied during active treatment, wherein fixed appliances are conventionally used to re-shape the deformed dental arches and develop anchorage for antero-posterior movement, one would be able to treat cases, as it were, with the "brakes off." Previously our best technical endeavours, more particularly in the grosser types of these deformities, were hampered from the very outset by the persistence of perhaps the most powerful factors in the whole symptom complex of these conditions.

One could, while re-shaping narrowed maxillary arches and retracting protruding maxillary incisors, at the same time remove, certainly during half the day at least, the cushioning effect of the lower lip, and take it at once from an obstacle to treatment into a force, in conjunction with the upper lip, working continually to produce movement in the desired direction. Also by virtue of the negative pressure induced within the oral cavity, the atmospheric pressure working outside the mouth and through the oral screen facilitates retraction of the maxillary incisors.[1]

Method of Wearing.

Once intermaxillary anchorage is adequately established, and even in some cases, say where upper first pre-molar extraction has been

*Read at the 12th Australian Dental Congress, Sydney, August, 1950.

undertaken and intramaxillary anchorage utilised, oral screens can be placed to commence their valuable work in treatment. Most, if not all, of the patients on whom this therapy has been used would come in the category of the more severe types of this class and their deformity would be characterised by their complete inability to close their mouths without considerable muscular effort and concentration (Fig. 1). Therefore it would not be expected that they would be able to close

Fig. 1 (a).

Fig. 1 (b).

their mouths easily over the screen superimposed over their incisors, and for this reason in the initial stages of wearing, a conditioning period would be required before the patient could be expected to wear the screen throughout the night. Instructions to these patients suggest that at first the screen would be worn for a quarter of an hour, half an hour, one hour, then up to two hours, say before retiring—while doing homework, playing the piano or even listening to the wireless.

Fig. 2.

When it is thought that the screen could be tolerated for a longer period, it was then suggested that they retire early and the parents watch them periodically before they themselves retire, to see that it is being worn satisfactorily and comfortably. The main adverse tendency is for the lower lip to droop in relaxation and come below the border of the screen, thus tending to dislodge it. To prevent this, light sealing with plaster, always protecting the mucosa of the lips, has been found effective. Once the screen has been worn all night for a week or so the patient adjusts himself to its persistent and regular use, and as he sees and senses improvement of his condition, he co-operates the more readily and enthusiastically. It might here be remarked that almost without exception the first 10 cases wherein this therapy was applied were

Fig. 3.

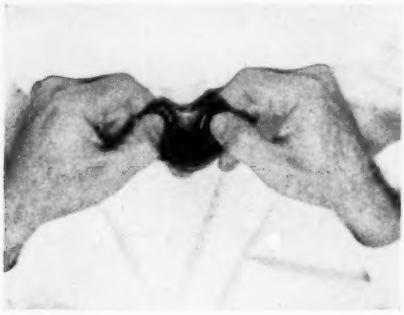


Fig. 4.—Impression immediately on removal, showing buccal widening by digital pressure.

country patients living hundreds of miles away. These patients were chosen not because they were country patients but because of the severity of their malocclusion. It will perhaps be conceded that a malocclusion would need to be of more than average complexity before parents living so far away would undertake the responsibilities incidental to treatment of these most severe types of malocclusion.

Fabrication of the Screen.

Preparation.

Before proceeding to the application of the oral screen, the full technical equipment called for in the treatment plan must be in place and working comfortably, the necessary settling in processes completed and the wearing of intermaxillary elastics commenced. In some mouths intramaxillary anchorage will also be used and it is important to make allowances in processing the oral screen to produce an easy and accurate fit over appliances, adequate room for the rubber ligatures, and freedom for the forward movement of the mandible. With the appliance in place, but not the inter- or intra-maxillary rubbers, an impression is taken in some resinous material of the vestibular area of the upper dental arch (Fig. 2) gaining as much height as possible back to the first molar area on each side (Fig. 3).

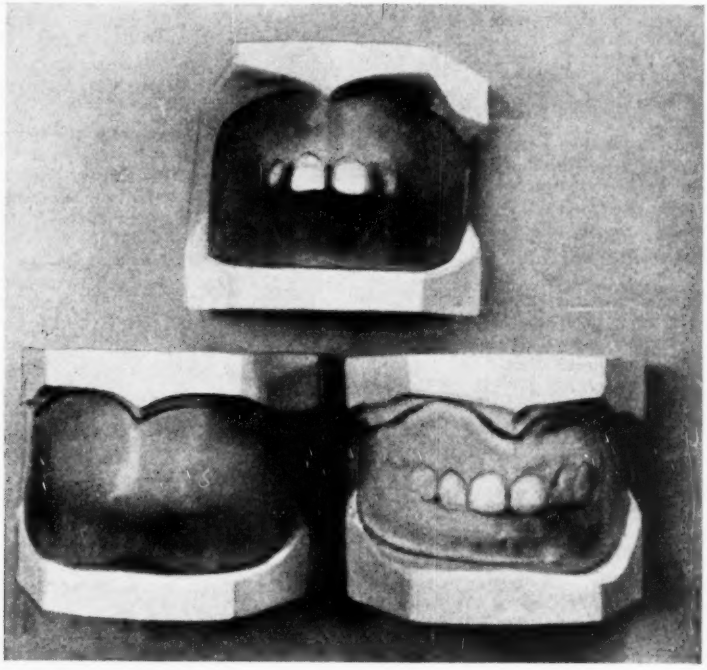


Fig. 5.—Stages of construction of screen for patient with post-normal mandible. (Casely, Rosamond.—Principles and construction of the oral screen as a functional appliance: Trans. B.S.S.O., London, 1947, pp. 81-7.)

Fig. 6.—(a) Oral screen in place over appliances.

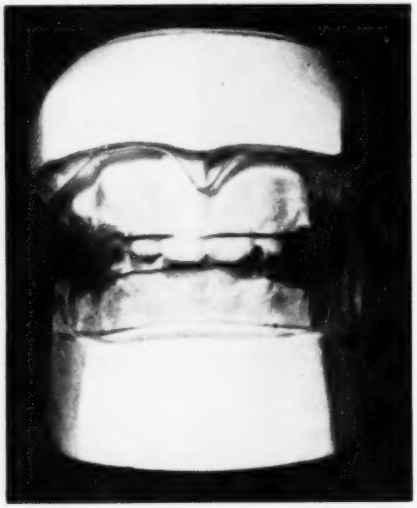


Fig. 6.—(b) Models from patient in 6 (a) mounted to show clear acrylic screen in place over actual appliances (Fig. 2) used in treatment.

(*Note*: Before the impression is taken a light strand of cotton wool is placed over the arch and round the brackets so that a smoother surface is presented to the impression material—an accurate impression of the arch and brackets is not at all to be desired. This cotton wool could be smeared lightly with oil or vaseline to prevent adhesion.)

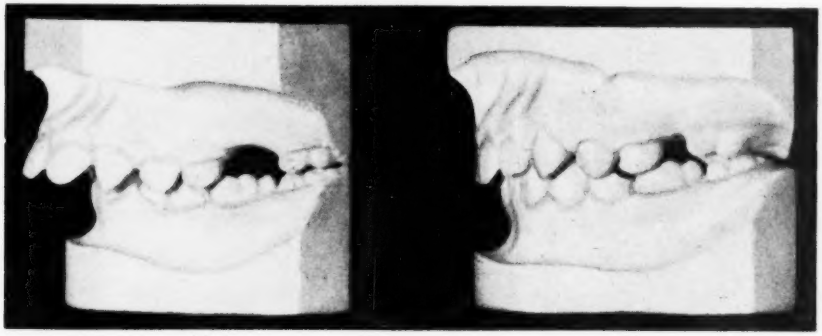
The impression is removed in the elastic stage, and on removal it is widened buccally by light pressure of both thumbs working evenly over the impression from the premolars backwards so that the impression is widened about 1 mm. on each side (Fig. 4). The anterior part of the impression is left undisturbed. It is to be noted that only an upper model is used in this technique as distinct from the conventional procedures associated with the fabrication of oral screens (Fig. 5).

It is felt that while some criticism may be levelled that this method may be a little haphazard, the author believes that it provides a more dynamic appliance than that achieved by the use of articulated models. When the model is produced, the screen is waxed up from one thickness of sheet wax, the screen periphery being pencilled on the model and the wax conformed to a smooth curve free-hand in such a design as to allow freedom for the mandible to move forward and at the same time prevent any binding in the alveolar area either anteriorly or posteriorly. Another reason for the free-hand contouring of the screen is that allowance can be made for the condition of the lips as well as for the degree of post-normality of the mandible (Fig. 6).

It is often a little hard at first for patients exhibiting the more severe degrees of this type of malocclusion to bring the mandible into contact with the maxillary incisors and approximate the lips for even the shortest time over the screen.

It is these patients who can be helped by the use of plasters to seal the lips over the screen, and the curve of the screen anteriorly can be so graded as to facilitate this approximation rather than cause a state of tension impossible of adaptation for the patient. As the upper dental arch widens and the incisors are retracted in association with the forward development of the mandible, making the mouth closure easier, the curvature of the screen can be modified if desired.

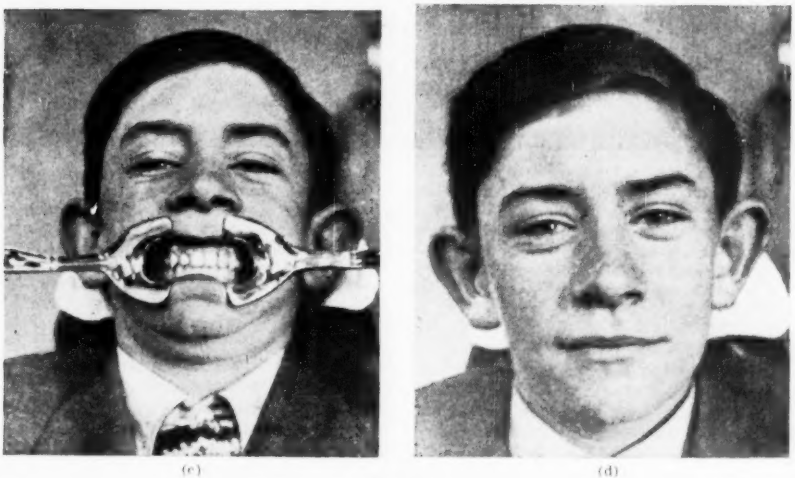
Case records will show that it has been possible to effect such a degree of improvement in these gross types of malocclusions as to transform habitual and fixed mouth breathers into children who can "reposefully" close their mouths within six months. By reposefully one means not only that the habit of nasal breathing has been developed, but that the lips can maintain mouth closure without evidence of strain or effort. This, to me, marks the turning point or the transformation of the mouth breather into a normal breather, for no matter how great the willpower, without the necessary muscle tone and denture balance, no permanence of mouth closure with normal respiration can be achieved.[2]



(a) (b)

Figs. 7 and 8.—*Case B.M. Boy aged* 12. Both upper first permanent molars were extracted before treatment because of severe caries; the upper first pre-molars were buccally placed and would have been preferably chosen for extraction. Appliances were placed 27/5/49. Oral screen was placed at the fourth appointment in August. Eight appointments for adjustments until 18/1/50 when plate and oral screen continued into retention. Note change in axial relationship of upper incisors—the change in cuspid relationship—the greatly reduced incisor overbite. Originally this patient was biting on the palate 3/16in. behind the lingual gingivae of the upper incisors.

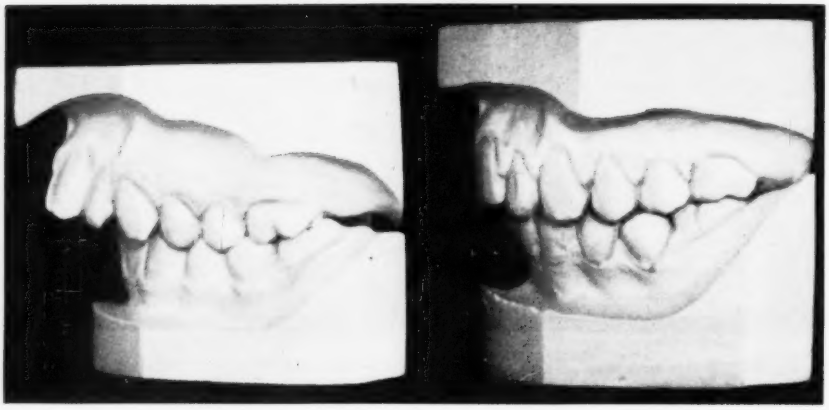
(a) (b)



(c) (d)

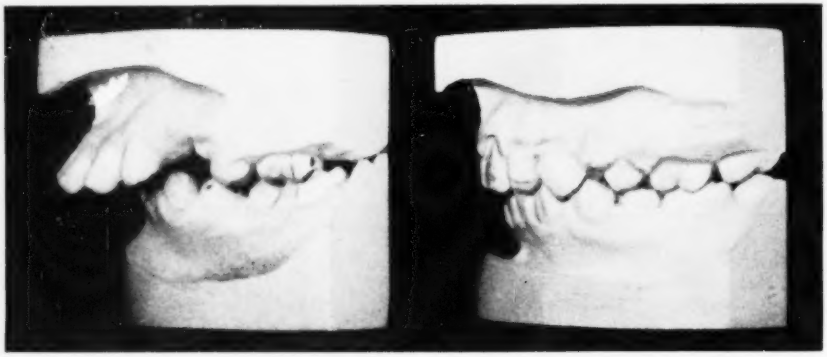
Fig. 8.

(a) and (b) are from photographs before treatment; (c) and (d) show patient seven months after commencement of retention, oral screen and plate being worn together at night.



(a) (b)

Fig. 9.—*Case F.D. Girl aged* 13. All first permanent molars were extracted before this patient presented for treatment. Appliances were placed 11/1/50 and seven appointments brought this case to the stage shown in models when the mouth was rested, and the oral screen continued in association with a removable plate retainer. The anchorage in this mouth tended to weaken and half a year's rest will be given before a final stage of treatment is undertaken. This child was one of the worst mouth breathers ever encountered, but now, after six months' treatment, mouth closure is possible without undue effort.



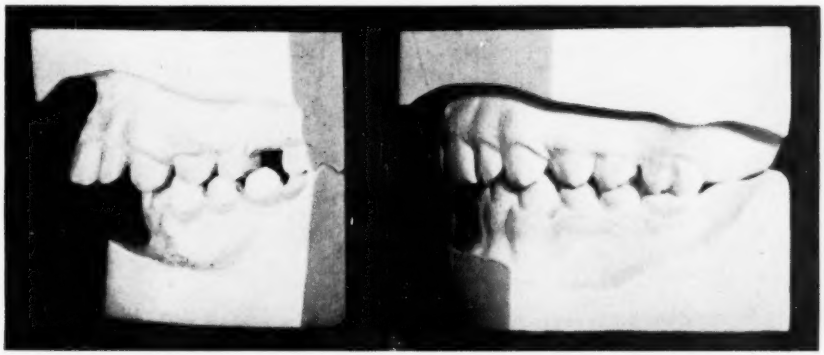
(a) (b)

Fig. 10.—*Case B.P. Boy aged* 13. Both upper first pre-molars were locked buccally and were extracted one month before treatment, which commenced 9/11/49. Eight appointments to retention on 5/7/50. Oral screen was placed at the third adjustment. Note change in axial relations of upper incisors—altered cuspid relationship—reduced incisal overbite. The pre-molar space is expected to close completely under retention embodying the continued use of the oral screen and a Hawley type plate retainer.

Use in retention.

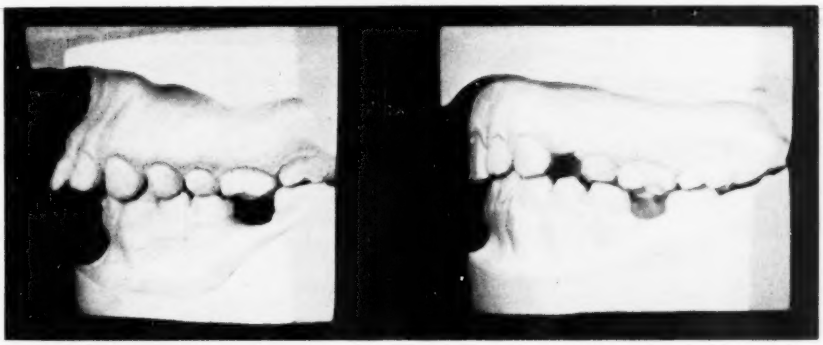
Towards the end of active treatment when normal arch relationships are established, or even within sight, treatment can be "eased up" as it were. From wearing intermaxillary rubbers at all times, day and night, the patient can be directed to wear them only at night, wearing the oral screen the while, of course, if it is the operator's policy to deband gradually.

At the stage of complete debanding, the conventional Hawley type retainers or even a Sved can be placed. The oral screen can be continued still as an active appliance, for the patient is by this time very well adjusted to its use and as the tooth movement has been



(a) (b)

Fig. 11.—*Case D.R. Girl aged* 16. All first four permanent molars had been extracted years prior to treatment. Appliances were placed 16/11/49. An oral screen was not placed until 10/5/50. Thirteen appointments were utilised for adjustments and appliances were removed 3/7/50. It is anticipated that due to this young lady's age a prolonged retentive period will be necessary so that the degree of overbite may be still further reduced.

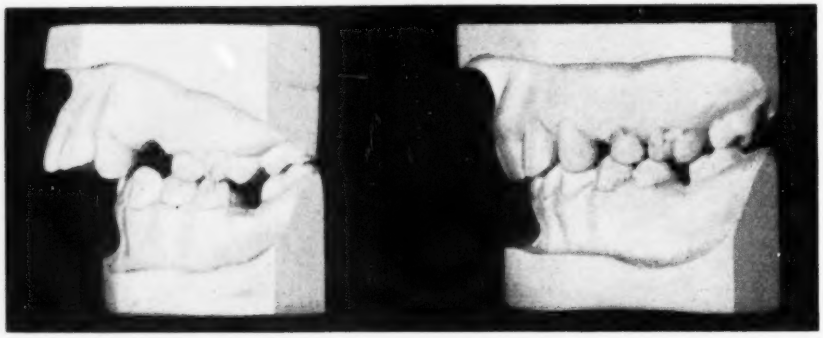


(a) (b)

Fig. 12.—*Case D.C. Girl aged* 14. An oral screen was used intermittently in 1946/47 but was not particularly effective. Due to the loss of both lower first molars before treatment the upper first pre-molars were extracted in August, 1949, and treatment was commenced in September, six appointments being needed for adjustments, and the appliances were removed in May, 1950. Oral screen was worn throughout treatment. Note change in axial relationships of the upper incisors and the decreased incisal overbite. The spaces remaining where the teeth were lost should continue to close; it is to be noted that extractions were not considered to be desirable in this case. The lower molar spaces should be restored.

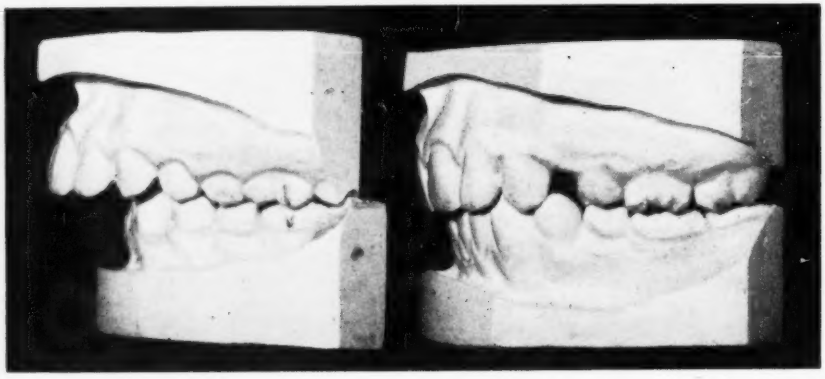
quite often spectacularly fast, the patient will have developed an enthusiasm for the screen, and will not mind carrying on its use as an influence in retention, which will further encourage normal development, muscular balance, normal breathing and similar favourable tendencies.

One does not wish to imply that within 6 to 8 months, which is the average time occupied in treatment of cases here presented, a significant mandibular development has been achieved. From clinical records one has learned to expect a considerable degree of osseous development as well as mandibular repositioning in many treated cases that fall within the category of Class II, Div. I, malocclusions. There are, however, some who, while normal respiration is achieved with mouth closure as a fixed habit, never gain any significant degree of mandibular develop-



(a) (b)

Fig. 13.—*Case A.C. Girl aged* 15. Both lower first permanent molars were lost at 11 years. Both upper first pre-molars were extracted before treatment. Appliances were placed 30/6/48. Eight appointments to 3/12/48. Oral screen was used in the later stages of treatment and used with plate retention, to continue normal development. Note change in axial relationship of upper incisors to the extent of over-treatment—almost complete closure of pre-molar spaces—the incisal overbite is still deep.



(a) (b)

Fig. 14.—*Case R.K. Boy aged* 12. Corrective measures were adopted as a first step and an oral screen was placed in January, 1949, and a removable "bite" plate was placed in the following May. Both upper first pre-molars were extracted in November due to the excessive prominence of the pre-maxilla. Fixed appliances were placed 20/12/49, when the oral screen was modified and its use continued. Thereafter six appointments were utilised until the appliances were removed 17/7/50, followed by screen and plate retention. Note improved axial relationships of the upper incisors—the altered cuspid relationship and the reduced incisal overbite.

ment. These are the true micro-mandibular types.

One would need the technique of cephalometry to evaluate the bone changes incident to treatment, but today my case reports are of an essentially clinical nature, and one looks forward with interest and confidence to have the results of the technique here presented critically and scientifically evaluated. The following cases were treated according to this plan (Figs. 7-14).

175 *Macquarie Street, Sydney.*

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Case Reports

Internal Resorption of the Tooth

B. G. Broadbent, M.D.S. (Syd.) and J. Brodie, B.D.S. (Syd.)

Two patients recently presented with radiographic evidence of internal resorption of the tooth. Their case histories are:—

1. V.W., a young woman, aged 24, complained of her upper left central being "tender to bite on". This had existed for one week. The tooth had no cavity and had received no attention for nine years when a gold inlay had been placed in the mesial; some time before that a lingual pit amalgam had been inserted. There had been no history of trauma or discomfort from the tooth in the intervening years and it was not discoloured. There was only slight sensitivity to extreme thermal changes. A radiogram (Fig. 1) revealed considerable resorption of the dentine from the pulpal surface midway between apex and crown which apparently had not perforated the root. The pulp canal was opened through the lingual and found in a state of liquefaction except for an almost indiscernible piece of tissue gathered from the apex on a barbed broach.

Fig. 1.

Fig. 2.

The root was treated and after four weeks was filled with OXPARA and gutta percha points. Apicectomy did not appear to be indicated. The post-operative radiogram (Fig. 2) shows no obvious perforation despite pressure developed during the packing of the root canal. Not enough time has elapsed to confirm success of this case but the tooth has been quite normal to the patient for nine weeks subsequent to completion of treatment.

2. F.D., a male aged 16, complained of slight pain in the upper left lateral incisor. It was only slightly tender to percussion. There was no caries present. It had been restored with a gold inlay mesially, an amalgam in the cingulum five years previously, and a gold inlay distally four years previously. There had been no soreness till two or three days before he presented for examination.

There was a history of trauma when the left central and lateral were slightly chipped but the patient could not remember when this had happened. The tooth was a little discoloured. Radiographic examination (Fig. 3) revealed a pea-shaped area of resorption of the dentine about half way from the apex to the crown. It could not definitely be established from the radiogram whether the root was perforated. The root canal was opened through the lingual amalgam and the pulp was found to be putrescent. The canal was cleaned and treated ten times, the treatment being done once or twice a week. As there was no improvement then the tooth was extracted and a partial denture was inserted. It was found that the root was perforated at the site of the resorption.

Fig. 3.

The interesting aspects apart from histology and cause of both cases were the abruptness of onset of discomfort and the lack of recent trauma or treatment.

Full mouth radiograms in both cases revealed no other similar conditions and both patients were physically well.

Bank of N.S.W. Chambers, Brisbane Street, Tamworth.

Compound Composite Odontoma

W. J. Harvey, B.D.S. (Syd.)

The patient, a male aged fourteen years, presented for dental examination, which revealed rampant caries, malocclusion and severe gingivitis.

Full-mouth radiographs were taken and the film of the mandibular right incisor was especially interesting. It revealed an encapsulated mass of radiopaque nodules within the alveolus, between the roots of the cuspid and lateral incisor teeth. This extended from the cortical plate of the crest of the intraseptal bone to the level of the apex of the lateral incisor. (Fig. 1.)

On clinical examination, no obvious signs indicated the presence of the anomaly, and its revelation came mainly from radiographic evidence, except a slight elevation of the buccal tissues in the mandibular right lateral incisor cuspid region. The slight swelling was quite hard, immovable and incompressible.

The patient complained of no symptoms and could give no history of discomfort in the area. Slight looseness and obvious irregularity in position of the lateral incisor was observed.

With the necessity of extraction of various non-vital teeth, including the mandibular right central incisor, it was decided to remove the anomaly.

The mandibular right central incisor was extracted, and the lateral incisor also, because of its looseness and displacement.

A mucoperiosteal flap was raised from the labial aspect of the area, and sufficient cortical bone removed to give good access for enucleation. This revealed fibrous tissue presumed to be the encapsulating tissue of the anomaly.

It was planned to remove the mass *in toto* by enucleation but, on attempting this, the tissue was found to be very friable and broke up, revealing many small calcified bodies, pulpy soft tissue and a very small amount of fluid.

The contents were removed piece by piece, with difficult and uncertain removal of the remnants of the fibrous sac, the walls of the cavity being cauterised to ensure complete elimination. The sharp edges of the bony cavity were smoothed over, sulphonamide monacrin powder insufflated and stirred into the blood clot and the wound sutured.

The patient was seen next day and reported no pain or discomfort. The sutures were removed on the fifth day, healing being uneventful. The adjacent teeth had suffered little and appeared to have good prospects of being useful.

The calcified bodies, twenty-four in number, varied in size from 0.75 mm. to 9.0 mm. and appeared, in several instances, to consist of normal enamel and dentine formed into misshapen teeth and, in others, just disordered masses. (Fig. 2.) The soft tissue within the sac had the appearance of avascular pulpal tissue. No histologic section was made.

The patient reported for radiographic check eight weeks following operation, and clinical examination showed the healing to be complete, the tissues healthy, and no evidence of the operation visible. The neighbouring teeth were quite firm and radiographically gave no evidence of any pathological change. (Fig. 3.) Normal bone formation appeared to be in progress.

137 *Beardy St., Armidale.*

Fig. 1.

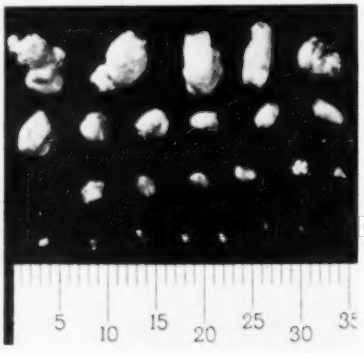

Fig. 2.

Fig. 3.

Dental Materials*

Current Notes No. 16

The Kneading of Impression Compound.

Before using impression compound it is usual to knead it in warm to hot water. The purpose of this manipulation is to obtain satisfactory working properties uniformly throughout the mass of material, the water being used as a convenient and steady source of heat.

It is now clear that the water has not only the passive and temporary role of a heat transfer medium but it radically affects the working properties of the compound. This was brought home in a striking manner during a series of tests on modelling compounds being conducted at the Bureau of Dental Standards. One of the laboratory tests laid down in Australian Dental Standard No. T6 is for impression taking ability and for it a disc of the compound is cut from a cake, flamed, brought to 45°C., then pressed under a load on to a test block which has been engraved with grooves of various depths. It was found that some products failed in this test when the discs were cut as specified, but passed with ease if the material was kneaded at any time prior to the test. This was found not to be a transient effect of working, but the change brought about by kneading persisted for weeks.

A quantitative way of estimating the effect of kneading is to use the specified plastic deformation or flow test. In this test a cylindrical specimen of the compound is heated to the test temperature then submitted to a standard compressive force. The decrease in height of the specimen after 10 minutes is a measure of the plasticity of the compound and obviously a satisfactory product must be very plastic at the working temperature yet show minimal flow at mouth temperature. Although not the only factor governing impression taking ability, plasticity is one of the most important and it is this property which is so markedly affected by kneading.

It is interesting to note that in U.S. specifications cast specimens are used for preparing the flow specimens. By this means very reproducible results are obtainable, and all would be well if all compounds responded to kneading to the same degree. It has been found that this is by no means the case and since compounds are kneaded in practice a test on cast specimens would not be the most reliable guide to performance.

To demonstrate the personal differences in kneading one modelling compound which gave a plastic deformation for cast specimens of 2% was selected and submitted to different operators. These were asked to knead the material according to strict conditions of temperature and time. One operator produced a material after kneading for 20 seconds which gave a plastic deformation of 6%. Another operator obtained a result of 9%. With 3 minutes kneading the first operator raised the figure to 24% whereas with the other operator a plastic deformation of only 11% was obtained. With four other operators a variety of results between these extremes was obtained.

It may be of significance that the person whose efforts at kneading gave a figure of 24% was a woman chemist who, quite apart from any domestic experience, had worked for some time in a flour mill laboratory where the testing of bread doughs plays such a prominent part. Whatever the reason there is no doubt that some operators are much more efficient in kneading compound than others. Even though care is taken to keep conditions the same, the way in which the compound is folded and pressed in the fingers is critical.

This has an important application in dental practice, even today when impression compound is used much less than it was formerly. Too much kneading in water will spoil an otherwise satisfactory compound in that its plasticity at or below oral temperatures, and hence its liability to distortion, will be increased. Further, every time compound is kneaded its properties will be affected. The re-use of this material would have the effect of prolonged kneading with consequent deterioration in properties.

The actual cause of the more or less permanent effect of kneading on plasticity has not been elucidated but there is little doubt that the water which is incorporated into the compound acts as a plasticiser. The extent of the change in properties will depend on the affinity of the material for water and the way in which the water is incorporated.

*Contribution from the Commonwealth Bureau of Dental Standards.

The DENTAL JOURNAL of AUSTRALIA

Editorial Department

Chlorophyll Dentifrice—Present Status

In recent years there have been numerous attempts to develop a therapeutic dentifrice, one which would not only clean the teeth but also interfere with those bacteria responsible for the pathological changes in the gums and teeth.

The ammonium ion, both in dentifrices and paste, has received considerable publicity and has been advocated by many manufacturers and some dental authorities as an efficient means of caries control. However, several studies, one by Kerr and Kesel[1] in Illinois and another by Davies and King[2] in New Zealand, have shown that these dentifrices have little or no effect on dental caries experience.

The incorporation of chlorophyll in toothpaste, although in use in the United States for the past several years, has only recently been advertised in this country. Some indication of the boom in sales of goods containing chlorophyll may be seen from the fact that last year the sales amounted to 50 million dollars, while in 1951 there were 22 million dollars, compared to several thousand dollars in 1946, the first year they were introduced.[3] Now there are over 150 consumer products containing chlorophyll in the United States.

The principal property claimed for chlorophyll preparations is their deodorising action which, according to a statement issued by the U.S. Federal Food and Drug Administration, expresses "scepticism concerning the effectiveness of the deodorant action".[4] Similar doubts have been expressed by the American Medical Association as to the value of these preparations.[5]

The American Dental Association first commented on the chlorophyll toothpaste following the publication of a magazine article.[6] In this article claims that "chlorophyll used as a dentifrice can control or stop the major manifestations of gingivitis and simple pyorrhoea as well as trench mouth" are made and also that the chlorophyll toothpaste "delivers a knockout punch to unpleasant breath and the bacteria linked with tooth decay".

The report given by the Council on Dental Therapeutics of the American Dental Association on Chloresium toothpaste (a typical chlorophyll dentifrice) is as follows:

> These case reports are unimpressive as evidence in support of periodontal therapeutic claims made by the firm. The photographic evidence reveals nothing that is not routinely accomplished by basic measures without the use of Chloresium products. In a number of these cases several therapeutic measures were employed; yet the results were attributed to the use of Chloresium products, without the benefit of controls. As judged by the photographic evidence in several of these case reports, doubts may be expressed with reference to the diagnosis and statements concerning aetiology.[7]

Members of the profession were advised to adopt a conservative attitude and the Council pointed out that "the available evidence gives rise to grave doubts about the remarkable statements concerning this dentifrice".

During the past year several reports have appeared in trade journals which indicate that chlorophyll dentifrices had deodorising properties. Barail[8] tested a paste containing 0.1% sodium copper chlorophyllum on 50 subjects, measuring the mouth odors remaining after the use of a chlorophyll dentifrice, but on critical analysis of the experiment the results did not appear conclusive.

The further claims that chlorophyll will decrease mouth organisms, dental caries and gingival disease have been extensively publicised by newspaper advertisements which lack scientific foundation.

Several years ago Griffiths and Rapp[9] showed that water-soluble chlorophyll reduced the *Lactobacillus* count of the mouth and Kesel[10] quoted a further trial of Gurney and Rapp, where in a group of 90 subjects 90%

had a negative *Lactobacillus* count after 26 weeks' use of "chloresium" toothpaste. The effect on the dental caries incidence *was not determined nor has yet been determined in the human.*

Preliminary experiments on the effects of chlorophyll on experimentally induced caries in animals have shown that the use of drinking water containing 1:500 sodium copper chlorophyllin by Syrian hamsters on a caries-producing diet showed a marked reduction of caries in the females only.[11]

A further report[12] by the same workers in 1951 showed a purer form of chlorophyll of 93.2% purity. A 1:500 solution of chlorophyll was used by the hamsters for drinking and after 110 days on a caries-producing diet, both male and female animals showed a reduction in caries. No explanation has been offered of the caries-inhibitory action of chlorophyll and to draw any conclusions from the results of these animal experiments would be premature.

A recent clinical study to determine the effects of a chlorophyll dentifrice in a group of 114 women aged 19 to 22 years, half the group being used as a control, has been made. A toothpaste containing the usual percentage of chlorophyll (0.1%) was used for a six months' period. The study was a very comprehensive one as the following author's abstract indicates:

> Tests or examinations were performed at monthly intervals for the following: gingival pathology, salivary lactobacilli, salivary odor, amount of stains, and amount of oral debris. In addition, for the final 4-month period, streptococcus counts, salivary pH and salivary acid production from glucose were determined at monthly intervals. . . . . No significant differences between the control and experimental groups were found for any of the factors tested.[13]

It would appear from the available evidence that there is little scientific support for the therapeutic claims of a chlorophyll dentifrice, and that advertising claims have generally been exaggerated and unfounded.

If the public are led to believe that this toothpaste is the panacea for all dental disease, then the complacency which is induced will lead to the ignoring of the previous practices advocated for the control of dental disease and the maintenance of oral hygiene.

Until evidence is available to indicate the real value of the chlorophyll dentifrice the profession should adopt a conservative attitude towards this subject.

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Current Literature

THE EFFECT OF SELF-CURING RESINS ON THE DENTAL PULP. H. A. Zander, D.D.S., M.S., Oral Surgery, Oral Medicine and Oral Pathology 4:1563 (December) 1951.

A preliminary investigation concerning the biologic properties of five resin materials is presented. Gingival third cavities were prepared and restored in 72 teeth of six dogs about one year old. Zinc oxide and eugenol and silicate cements were used for comparison. Teeth were removed for sectioning after sixty days.

For each filling material tested, there were some pulps which showed no inflammation or irregular dentine formation and some pulps which showed varying degrees of chronic inflammation or irregular dentine formation or both. No single resin material can be said to be completely non-irritating to the dental pulp. No single resin filling material caused a severe enough inflammatory reaction to label it as being severely irritating. Discussing these results, Zander claims that the irritation observed may be due to certain physical properties such as expansion or contraction or shrinkage, rather than the material per se, and also adds the reminder that this experiment was carried out on perfectly sound teeth, while in general practice these teeth are not restored. If the pulp is previously inflamed, any one of the filling materials may provide the necessary added irritation to cause severe pulp damage.—*J.L.*

THE RESPONSE OF THE HUMAN PULP TO SELF-POLYMERISING ACRYLIC RESTORATIONS. I. R. H. Kramer, L.D.S., and J. W. McLean, L.D.S., British Dental Journal 92:255-61 (May) 1952, and 92:281-7 (June) 1952, and 92:311-5 (June) 1952.

An investigation is reported which attempted to determine the pulp reaction following the insertion of various self-polymerising acrylic resins into cavities prepared in non-carious human teeth. In addition the modification of the pulp reaction to the unlined material resulting from the use of cavity linings and medications such as zinc oxide and eugenol, zinc oxyphosphate cement, acrylic in chloroform, cellulose acetate in acetone, phenol and silver nitrate, was investigated. (Of these cavity liners and medications, zinc oxide and eugenol, acrylic in chloroform, cellulose acetate in acetone, phenol and silver nitrate are known to be unsuitable for clinical use, by reason of chemical incompatibilities which result in undesirable changes in the filling materials.)

The preparation of the teeth for histological examination and the establishment of satisfactory criteria for the assessment of pulp response are described in detail.

In this series of experiments there was no marked variation in the pulp response to five self-polymerising acrylic restorations when these materials were used in unlined cavities.

Pulp response in those experiments in which a resin was inserted after cavity lining corresponded to the response that might be expected to the lining material.

No pulp death was recorded in these experiments and this suggests that the usual outcome of the inflammatory pulp changes described is resolution.

The authors point out that definite conclusions cannot be drawn from their experiments in which the numbers exactly comparable are small. The results of methods used in these experiments suggest that when the materials tested are employed in normal clinical practice, and particularly when used for the restoration of carious teeth, the pulp reactions are likely to be less severe.—*J.L.*

THE EFFECT OF DIRECT FILLING RESINS ON THE TOOTH PULP. Alexander Seelig, D.D.S., New York, The Journal of the American Dental Association, 44:261 (March) 1952.

Seelig has investigated the effect of the insertion of the material into prepared cavities in animals' teeth and found that the material itself produced no deleterious effect on the pulp. Other causes of pulp injury were investigated.

The adaptation of the direct filling resins to the cavity walls is shown to be excellent whether the Nealon or so-called pressure method is used; however, the early removal of the matrix when employing the pressure technique causes leakage with subsequent pulpal irritation. The technique described by Nealon gives a less porous filling and eliminates some of the difficulties of the pressure method.

In the case of pulp injury, the diagnosis, the cavity preparation and the techniques of filling should be examined before direct filling materials are condemned.—*J.L.*

AUTO-POLYMERISING RESIN FILLINGS. Herbert D. Coy, D.D.S., David M. Bear, D.D.S., and Seymour J. Kreshover, D.D.S., Ph.D., Richmond, Va., The Journal of the American Dental Association 44:251 (March) 1952.

A clinical and experimental study of the usefulness of auto-polymerising resins for permanent restorations is reported.

In the clinical study a total of 600 teeth were restored over a sixteen month period. The technique used was the ordinary mixing of the monomer and polymer and the application of definite pressure to the material in the cavity during polymerisation. Details of cavity preparation, mixing and insertion of the material and types of matrices are given.

Periodic examination was attempted of the 600 restorations (in 300 patients). Fifty patients were re-examined after three months and forty after one year. The tabulated results one year after insertion of the 105 restorations which could be re-examined show 5 pulp deaths, 4 leakages, 15 stained or discoloured. Nineteen fillings were replaced for all causes. (The authors claim that the pulp deaths may have resulted from the use of any filling material, as these teeth had been the seat of deep carious lesions.) In deep seated cavities a cement base over a lining of calcium hydroxide is recommended, and no liner in cavities of normal depth.

In the experimental study 72 restorations were inserted in the teeth of four dogs. The histologic findings suggested that the pulpal response, although of a pathologic nature, is probably a reversible one.

All restorations demonstrated a tendency to yellowish discolouration. It was also observed that the material flowed under stress and therefore is not indicated for use in stress-bearing areas.

The technique of insertion is more difficult and time-consuming than for silicates and the authors recommend further clinical and histologic study before this material is adopted for indiscriminate use.—*J.L.*

VASCULAR NETWORK AND HARD TISSUES IN THEIR RELATION TO THE EARLY TREATMENT OF VITAL HUMAN TEETH. (Gefaessnetz und Hartgewebe in ihren Beziehungen zur Fruehbehandlung des vitalen menschlichen Zahnes.) Guido Fischer, Deutsche Zahnaerztliche Zeitschrift, 7:57-72 (January 15) 1952.

This article contains a comprehensive compilation of observations on the biology of human teeth. An abstract can deal with such a great amount of information in a very rudimentary way.

In a vital tooth, all the processes of formation, preservation and healing of tissue are guided by the branches of a "vegetative terminal reticulum" (Ph. Stoehr) which permeates all hard tissues: enamel, dentine, cementum. This reticulum is part of the connective tissue system of the tooth. It is closely related to the outer connective tissue coat (adventitia) of the blood-vessels of pulp and periodontal membrane, and carries the blood plasma to the hard substances of the tooth. The ultra-capillaries of this network are too narrow to allow for the passage of the cellular elements of the blood.

This reticulum of ultra-capillaries in the tooth is compared with the reticular systems found in other organs of the human body. While pulp and periodontal membrane are providing, with separate elements, the continuity with both the vascular and nervous system, the reticular fibres are agents of both systems, carrying the vitality of the organism and the fluctuations of its vitality right to the surface of the teeth.

The enamel cuticle has been described as a terminal membrane consisting of a network of reticular fibres. Caries and periodontal disease are related to fundamentally endogenous conditions.

Nerval-hormonal and general dystrophies are the fundamental causes of a weakening which leads to ailing of the hard dental tissues.

The healing power of the hard tissues depends on the plentiful supply of plasma and the absence of irritation and infection.

When there is an injury to the vital hard tissues enamel and dentine, . . . it is sealed in a well re-active tooth by blood plasma, which coagulates to fibrin, and out of this comes scar tissue.

According to the author, it forms a membrane covering the walls of a cut cavity. However,

in an individual with caries disposition, . . . here and there the fibrin necrotizes and forms a substratum for bacteria (Forshudvud).

No healing can take place in a cut surface unless the method of treatment and the nature of the inserted filling material are acceptable to the tissues and do not cause irritations. To keep all sorts of irritation away, the author recommends the use of a continuous water spray of body temperature during cavity preparation.—*F.T.*

THE FERMENTING PROPERTIES OF SEVERAL CARIES ORGANISMS AND OF BACTERIUM ACIDOPHILUM EXAMINED ON VARIOUS SPECIMENS OF CARBOHYDRATES AND THEIR INFLUENCE ON THE PH OF SALIVA. (Das Spaltungsvermoegen einiger Karieskeime und des Bact. acidophilum und deren Reaktion auf das Speichel-pH.) Ernest Sauerwein, Deutsche Zahnaerztliche Zeitschrift, 7:73-87 (Jan. 15) 1952.

In a short review about the significance of *Bacterium acidophilum* in the aetiology of dental caries according to the Michigan School and the role of the carbohydrates, especially sugars and sweets, new research results are cited which seem to be qualified—according to the author—to correct the existing conception in the following points:—

(a) The *Lactobacilli* are to be regarded, with great probability, as indicators of the onset of caries or existing caries, but not as the specific cause of caries.

(b) The control of *Lactobacilli* by means which are effective in the laboratory has only satisfied clinical expectation to a modest degree.

(c) The result of two years of experiments with a dentifrice containing diammonium phosphate urea (Kesel) was that, compared with a non-medicated dentifrice, a caries reduction of approximately 10% could be obtained.

In order to assess the caries potential of carbohydrates and sugars, 37 commercial varieties of carbohydrate were investigated with regard to fermenting capacity and pH changes of saliva after intake. The results are summarized as follows:—

1. Sucrose, which is mostly used in the manufacture of confections, was not fermented by most of the strains of *B. acidophilum* cultivated by the author, with the exception of the types A-C. However, by adding other sugar compounds, fermentation of nearly all the specimens in the experiments was induced.

2. *Staphylococci*, *Streptococci*, coli, yeast and mixed caries flora fermented all the selected carbohydrate specimens, with a few exceptions differing from organism to organism.

3. The amount of acid produced by the micro-organisms—the mixed flora excepted—was less than that of *B. acidophilum*. This organism, together with yeast, gave lower pH values than *B. acidophilum* or yeast for themselves. Mixed caries flora produced the maximum of acid.

4. After adding sterile filtrated saliva, carbohydrates are fermented by *B. acidophilum*, while they resist fermentation without that addition of saliva.

5. On the average, the pH of saliva increased after sugar intake, when the saliva was more acid than the ingested sugar compound. This could be proved for many specimens of saliva.

6. Acid-producing carbohydrates (sugars) cause considerable lowering—of short duration only—of salivary pH. This is quickly balanced by the buffering capacity of saliva, individually different but always adequate to control deviations within a short time.—*F.T.*

News and Notes

Standardisation of Dental Products

Some confusion appears to exist regarding the functions of the various bodies connected with standards. In order to clarify the position, an outline is given of the procedure adopted and the various functions carried out in accreditation of a material and its being listed a certified dental material:—

1. The function of the Standards Association of Australia is to draft and promulgate a specification for a material.

2. The function of the Commonwealth Bureau of Dental Standards is to carry out research and tests under the auspices of the Commonwealth Department of Health. Its facilities and advice are available to the Standards Committee of the Australian Dental Association.

3. The *only* accrediting body is the Standards Committee of the Australian Dental Association and all applications for accreditation should be addressed directly to it at 147 Collins Street, Melbourne.

A close liaison is maintained between the three bodies mentioned above and complete agreement on each specification is reached before its issue.

13th Australian Dental Congress Brisbane, June 1-5, 1953

Congress time approaches rapidly.

The Congress Booklet distributed by the Congress Commission in Queensland is evidence that the members of the Commission are working hard and efficiently to ensure that the 13th Australian Dental Congress will be an outstanding success.

Although nothing definite is yet known as to who will comprise the representatives from overseas, correspondence is still passing between the Commission and members of the profession both in the United States and in the United Kingdom regarding possible visitors from abroad. It is hoped that representation by the American Dental Association at the Congress will be obtained through the efforts of Professor S. F. Lumb, Dean of the Faculty of Dentistry at the Queensland University and President of Congress, as this will help strengthen the professional and international bonds between the two countries.

The Honorary Secretary of Congress, Mr. H. W. Russell, who is also President of the Queensland Branch of the Australian Dental Association, when recently in Sydney spoke enthusiastically of the interest being displayed throughout the Commonwealth by intending clinicians and, to enable the Commission to establish early a strong framework of Scientific Programmes, members are requested to contact the Vice-Chairman of their Section in order to facilitate further the early arrangement of the Scientific Programme.

Chairmen and Vice-Chairmen of Sections.

Crown and Bridgework and Ceramics.

Chairman: Mr. F. R. Somerset.

Vice-Chairmen:

New South Wales: Mr. W. Alan Grainger.
Victoria: Mr. I. Jacobs.
South Australia: Mr. M. S. Joyner.
West Australia: Mr. G. M. Stott.
Tasmania: Dr. K. J. Cassidy.

Operative Dentistry.

Chairman: Mr. J. O. Pearn.

Vice-Chairmen:

New South Wales: Mr. J. S. Lyell.
Victoria: Mr. J. LeB. Warren.

South Australia: Dr. G. O. Lawrence.
West Australia: Mr. R. V. Johnson.
Tasmania: Mr. M. H. Rosenberg.

PROSTHODONTIA.

Chairman: Mr. E. D. Ramsay.

Vice-Chairmen:

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Victoria: Mr. A. R. T. Greenwood.
South Australia: Mr. M. J. Barrett.
West Australia: Mr. C. E. G. Abbott.
Tasmania: Mr. G. L. Carter.

ORAL SURGERY AND ANAESTHESIA.

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Vice-Chairmen:

New South Wales: Professor A. J. Arnott.
Victoria: Professor A. B. P. Amies.
South Australia: Dr. T. D. Campbell.
West Australia: Mr. G. D. Henderson.
Tasmania: Dr. G. Hurburgh.

PERIODONTIA.

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West Australia: Mr. G. I. Brindsen.
Tasmania: Mr. E. J. Pickford.

ORTHODONTICS, PEDODONTIA AND PREVENTIVE DENTISTRY.

Chairman: Dr. V. P. Webb.

Vice-Chairmen:

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Victoria: Dr. K. T. Adamson.
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Vice-Chairmen:

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Vice-Chairmen:

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Vice-Chairmen:

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Victoria: Dr. K. J. G. Sutherland.
South Australia: Dr. T. D. Campbell.
West Australia: Professor H. G. Radden.
Tasmania: Mr. D. Innes.

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Vice-Chairmen:

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Victoria: Mr. M. M. Sullivan.
South Australia: Mr. B. C. Crisp.
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Vice-Chairmen:

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Victoria: Dr. N. H. Andrews.
South Australia: Mr. R. G. Willoughby.
West Australia: Mr. R. S. D. Gargett.
Tasmania: Mr. R. G. Fitzgerald.

Fairfax Reading Memorial Prize

The Committee of Management of the Dental Alumni Society has announced the name of the recipient of the Fairfax Reading Memorial Prize for 1952.

The Fairfax Reading Memorial Prize is awarded biennially and has been awarded this year to Dr. N. E. Goldsworthy for his outstanding services in the development of dental research and teaching.

Dr. Goldsworthy is congratulated on receiving this prize in recognition of his work in this field.

Capital of U.S.A. Begins Water Fluoridation

Washington, the capital city of U.S.A., began to fluoridate its public water supply on June 23, 1952. The capital uses approximately 165 million gallons of water per day and will require about 2,800 pounds of sodium silicofluoride daily to bring the fluoride concentration up to the recommended 1 p.p.m.

The Washington treatment plants employ an automatic self-adjusting feeding mechanism which gives evidence of the operating procedures and has visible as well as audible warning devices to indicate any deviations in the fluoridation process.

In addition to the estimated 800,000 population of the District of Columbia, another 130,000 people in Arlington and Fairfax, Virginia, will receive the benefits of the new programme. The Washington Suburban Sanitary Commission is already supplying fluoridated water to about 300,000 people in 26 incorporated and 26 unincorporated communities in nearby Maryland. The 1,230,000 people served by these two fluoridation projects is believed to be the largest single population group in the United States to be benefited thus far.

(This report is reprinted from *Dental News*, July, 1952, a monthly newsletter published by the Public Health Service of the U.S.A. Federal Security Agency.)

Post-Graduate Course, Institute of Dental Surgery, London

A full-time Post-Graduate Course of approximately 6 months' duration will commence on 5th January, 1953, at the Institute of Dental Surgery (University of London), Eastman Dental Hospital, Gray's Inn Road, London, W.C.1. Further details may be obtained at the Office of the Association.

World Conference on Endodontics

The School of Dentistry, University of Pennsylanvia, announces a World Conference on Endodontics, which will be held from 21st to 27th June, 1953. Outstanding leaders in the field of Endodontics will participate in the Conference, which will be under the direction of Dr. L. I. Grossman. Applicants should address their enquiries to: Postgraduate Courses, School of Dentistry, University of Pennsylvania, Philadelphia 4, Pennsylvania.

Vacancy for Dental Officer, Territory of Nauru

Applications are invited from persons desirous of appointment as Dental Officer, Nauru. The salary rates quoted are actual and include Territorial Allowance and cost-of-living adjustments.

Salary range: £1,424-£1,514 per annum (Unmarried); £1,449-£1,539 per annum (Married). (Commonwealth Income Tax Assessment Act not applicable any income derived by resident of the Island from sources within the Island.)

Qualifications: Registered dentist in Australia or New Zealand.

Term of appointment: Two years first instance.

Leave: Three months after 21 months' service.

Applications: Showing full name, date and place of birth, qualifications, experience, marital state and accompanied by copies only of testimonials to Secretary, Department of Territories, Canberra, by 31st January, 1953.

Practices for Sale

Dental practice, old established, leading north-west coast Tasmanian town, for sale. Well equipped. Net profit £1750 p.a. Also modern house available for sale. Dental practices, leading Victorian country towns also for sale. Full particulars apply Bosch Naylor Pty. Ltd., 53A Russell Street, Melbourne.

Seaside suburb, beautiful rooms in modern flat; could use as a home if necessary. This successful practice has been established 62 consecutive years and has been in two hands only. Solid practice in a delightful and prosperous area. Write to the Secretary of the Association, 135 Macquarie Street, Sydney.

Property for Sale

Ideal property for dental practice. Modern all-electric home, vacant possession; with large outbuilding, 340 sq. ft., suitable consulting rooms or workshop; garage. Large lounge, 3 bedrooms, kitchen, bath, hot water service, built-in cupboards, well fenced, pathed, good drive, splendid position. 'Bus route. Price £4,800. R. Healey, 69 Pacific Street, Long Jetty, N.S.W.

Blue Mountains Division Sports Day

The Fifth Annual Sports Day of the Blue Mountains Division of the Association was held at the Leura Golf Club and the Katoomba Bowling Club on Friday, 3rd October, 1952.

A most enjoyable day was spent by members of the Division and visitors, and the Committee of the Division responsible for the organisation of this Sports Day is to be complimented on its success.

The winners of the events were as follows:

GOLF.

Fourball v. Par:

S. L. Jackson and J. E. McGovern. 8 up.

Scratch Score:

B. Stern and A. Kyd. 5 down.

First Nine:
L. Mackenzie and M. Griffin. 4 up (on count back).

Second Nine:
K. Hutchinson and E. H. Kelly. 5 up (on count back).

Long Drive:
N. Moore.

Putting Competition:
E. C. Weir.

BOWLS.

Winners:
W. B. Chesher and H. F. Carpenter.

Runners-up:
T. L. Emanuel and W. Hutchinson.

Association Activities

Australian Dental Association (New South Wales Branch)

GENERAL MEETINGS.

September.

The Ordinary Monthly Meeting for the month of September was the occasion of a lecture by Mr. C. Ritchie, B.D.S., on "Advances in Local Anaesthesia". Mr. Ritchie dealt with modern developments of technique and materials in relation to local anaesthesia and his address was much appreciated by members.

October.

The October General Meeting of the Association on 28th of that month heard a particularly interesting address by Mr. W. A. Grainger, M.D.S., who had just returned from an extensive visit overseas, during which visit he had investigated developments in dental treatment in America, the United Kingdom and Europe. Mr. Grainger's review of Overseas Trends in Dental Treatment was of great assistance to members attending and was much appreciated.

On this occasion the President, Dr. A. G. H. Lawes, at the desire of the Executive instituted the first of a regular series of reports to members on various aspects of Association activities at Ordinary Monthly Meetings.

EXECUTIVE REPORT.

Association finance.

The Executive has given full consideration to the activities and finance of the Association, both in the immediate past and future years, and has decided that, to maintain Association activities at the high standard of the past, additional funds through increased subscriptions is essential. Consequently, subscriptions have been raised in all forms of membership for the ensuing year.

Industrial matters.

The Executive has pleasure in reporting that a new Dental Assistants and Secretaries (State) Award has been finalised after a hearing by the Dental Attendants and Secretaries (State) Conciliation Committee. It is felt that several anomalies existing in the former Award, which was the first Award made for this class of dental employee, have been corrected and that the new Award should be quite satisfactory to members.

Fees for hospital dentures.

The Executive is pleased to report a successful issue to the negotiations entered into with the Hospitals Commission concerning fees payable through country hospitals for the supply of dentures to indigent persons, details of which have been forwarded by circular to members.

Fact-finding Committee concerning direct contractual relationships with the public by dental technicians.

The Association has been advised that the Minister for Health has approved of the setting up of a Fact-finding Committee in regard to proposals which have been made that the Dentists Act 1934 be amended to permit dental technicians to carry on dental work in direct contractual relationships with the public.

This Association, the Dental Board of New South Wales, the Dental Technicians' Association and the Social Services Committee of the Trades and Labour Council of New South Wales have been invited to appoint representatives to this Committee. Accordingly, the Executive has appointed the President, Dr. A. G. H. Lawes, and Mr. N. E. Edney, as the Association's representatives on the Committee.

It is understood that the initial meeting of the Committee will take place in the near future.

Annual Meeting of the Australian Dental Association.

The Annual Meeting of the Federal Council of the Australian Dental Association took place in Sydney on Saturday, 18th October, 1952.

The New South Wales State Branch was represented by two delegates in the persons of the President, Dr. A. G. H. Lawes, and Dr. F. E. Helmore, Vice-President.

A considerable number of matters of general and national import were dealt with at this meeting and these matters will be reported in due course in a Federal Newsletter published in this Journal.

On the occasion of this meeting the Federal Officers of the Association were elected for the ensuing two years. The election resulted as follows:

President: Dr. J. V. Hall Best.

Vice-President: Dr. K. T. Adamson.

Interstate Vice-President: Dr. J. M. Wark.

Hon. Secretary: Mr. N. E. Edney.

Hon. Treasurer: Dr. A. G. Rowell.

The meeting confirmed the appointment of Mr. E. F. Hewlett as Executive Secretary for the ensuing year.

The Office of the Association remains in Sydney at the direction of the President.

Reports of Association affairs at general meetings.

The Executive has decided that the President should from time to time on the occasion of Ordinary General Meetings of the Association present to members reports on general Association affairs. The first report by the President was made to the Ordinary Monthly Meeting on 28th October, and was well received by members.

Dental Journal of Australia.

The Executive has been pleased to continue the appointment of Mr. N. D. Martin, M.D.S., as Honorary Editor of *The Dental Journal of Australia* for the ensuing twelve months, and wishes to express the appreciation of the Association to Mr. Martin for his services and the high standard of publication of the Journal.

Hardwick Memorial Library.

The following new books have been added to the Hardwick Memorial Library:

Boyle, Design of the Natural Dentition	£1 19 6
Brauer and others, Dentistry for Children, ed. 3	£4 18 6
Drummond-Jackson, Intravenous Anaesthesia in Dentistry	£2 7 0
Moss, Hypnodontics	£3 17 0

Dental Health Education Department.

The Dental Health Education Department of the Association again wishes to remind members that ample supplies of dental health literature are available, a further edition of 40,000 copies of "Healthy Mouths" having been received from the printer.

The Dental Health Education Department and members of the Association again actively co-operated during National Health Week. The Dental Health Exhibit was shown at Leichhardt Town Hall; lectures were given and films were shown to schools and interested public bodies in Sydney and suburbs and in Newcastle, where members of the Newcastle and Hunter River District Division actively assisted. Radio scatters and literature were made available to the Health Week authorities and contributions were made to the Newcastle Health Week booklet.

The Dental Health Essay Competition took place in State and Catholic Schools throughout New South Wales during September and the essays are now being judged.

MEMBERSHIP.

Full members.

Caldwell, Lyle, B.D.S.; Girdler, Maxwell John, B.D.S.; Hudson, Arthur Lindsay, B.D.S.; Mann, Kenneth Joseph Henry, D.D.S., B.D.Sc., L.D.S.; O'Reilly, Peter John, B.D.S.

Leave of absence.

Boddy, I. A.; Carroll, R.; Sengelman, Miss B. M.

Deceased.

Spencer, Malcolm; Starkey, William Augustus.

Blue Mountains Division

The list of officers elected at the Annual Meeting of the Blue Mountains Division held on 15th November, 1952, is as follows:

Chairman: Mr. D. McEwan.

Vice-Chairman: Mr. D. Droulers.

Hon. Secretary: Mr. R. Mathews.

Hon. Treasurer: Mr. M. McEwan.

Committee: Mr. P. Clark, Dr. K. S. Hutchinson, Mr. Greg Niccol.

Nominee as Additional Member of the Executive: Mr. John Anker.

Far North Division

The Annual General Meeting of the Far North Division was held in Lismore on 15th November, 1952, and the following office-bearers were elected for the year 1953:

Chairman: Mr. H. W. Shand.

Vice-Chairman: Mr. W. Scotton.

Hon. Secretary: Mr. J. A. Bice.

Hon. Treasurer: Mr. K. M. Dagg.

Committee: Mr. B. J. Page, Mr. A. R. Duncan.

Nominee as Additional Member of the Executive: Mr. H. W. Shand.

Newcastle and Hunter River District Division

At the Annual General Meeting of the Newcastle and Hunter River District Division, the following officers were elected for 1953:—

Chairman: R. Krauss.

Vice-Chairman: R. H. Bruce.

Hon. Treasurer: D. Reynolds.

Hon. Secretary: H. Skinner.

Committee: B. Dyson, G. Solomon, J. Thomas.

Nominee as Additional Member of the Executive: G. Solomon.

South Coast Division

The Annual Meeting of this Division was held on Friday, 7th November, 1952. The following officers were elected for the year 1953:

Chairman: Mr. R. G. Esdaile.

Vice-Chairman: Mr. C. W. Stone.

Hon. Secretary: Mr. J. H. Palmer.

Hon. Treasurer: Mr. G. Meldrum.

Nominee as Additional Member of the Executive: Dr. J. D. Oddy.

Southern Division

At a General Meeting of the Southern Division held on 27th September last, the election of office-bearers in this Division was held. The result of the election was as follows:

Chairman and Nominee as Additional Member of the Executive: Mr. A. Broughton.

Hon. Secretary: Mr. J. G. Blakeney.

Hon. Treasurer: Mr. P. Caldwell.

Southern Tablelands Division

At a meeting of this Division held in Goulburn on 22nd November, 1952, the following members were elected as officers of the Division for the current year:

Chairman: Mr. J. Golding.

Hon. Secretary: Dr. R. D. MacCulloch.

Hon. Treasurer: Mr. K. R. Fisher.

Nominee as Additional Member of the Executive: Mr. M. Hamilton.

Committee: Mr. B. Reilly, Mr. D. Denney.

New Books and Publications

THE TEMPOROMANDIBULAR JOINT, edited by Bernard G. Sarnat, Springfield, Illinois, 1951. Charles C. Thomas (148 pages). Price 35/- (stg). *Our copy by courtesy of Blackwell Scientific Publications.*

This volume has been published as a monograph on the Temporomandibular Joint. The authoritative basic science pertaining to the masticatory apparatus is presented as a background for discussion of abnormalities and their treatment.

The publication has been compiled from papers and lectures by Sicher, Weinmann, Brodie, Zimmerman and Thompson, and much of the material is that presented through the Post Graduate Discussion of the University of Illinois College of Dentistry and included in the Post Graduate Long Distance Telephone Extension Broadcasts.

No attempt has been made to produce a complete review of the literature on temporomandibular joint disturbances, but a critical evaluation of the usually accepted theories is presented and suggestions made for future study.

The early chapters are devoted to functional anatomy, histophysiology and pathology of the joint and its contribution to the growth of the face. To anyone wishing to acquaint themselves with the growth factors of the face and serial cephalometric roentgenography, these chapters are especially recommended for their clarity of expression and logical construction. The information presented should be of interest to all dental practitioners, who would be well advised to concern themselves with the (temporomandibular) joint region.

The systems attributed to Costen's Syndrome are systematically examined in the light of the facts established in previous chapters and all excepting the neuralgias are definitely refuted with the conclusion that the syndrome as such should be abandoned. The authors stress the fact that temporomandibular joint disorders can only be interpreted after a very careful examination of the occlusion. They have shown that a static relationship of models is totally inadequate for observation must be along the lines of function, for the path of closure from rest to occlusal position must be determined either clinically or by cephalometric or temporomandibular joint roentgenograms.

A method of treatment of particular interest utilising acrylic splints for immediate use, with ultimate replacement by permanent dental restorations, is incorporated in a short section of case histories.

In all this is an excellent volume which should do much to stimulate research by the presentation of a reasoned approach to a field which until now has been complicated by a great many misconceptions and contradictions. —*C. H. Graham.*

ORAL PHYSIOLOGY, by John T. O'Rourke and Leroy M. S. Miner, St. Louis, 1951. C. V. Mosby Co. (333 pp.). Price 52/6d. *Our copy by courtesy of W. Ramsay (Surgical) Pty. Ltd.*

This book is one of the first to be written concerning the subject of mastication and its relation to general health. In the preface the authors state that "there is no good evidence to show that mastication is an isolated and meaningless function in civilized man," for it is often taken for granted that teeth are of little importance to health.

The authors proceed, after a brief introduction in which the prevalence of dental disease is discussed, to extensively review the subject of mastication. There are chapters on mastication of domestic animals, mastication in relation to deglutition, and to other parts of the alimentary tract, taste and smell and other sensations in relation to mastication and its significance in children.

The discussion on the patient with gastro-intestinal neurosis and dental deficiencies is particularly pertinent, and the following statement could be well affirmed by all associated with dental practice:—

> Obviously the lesson each dentist must learn from this is that he must recognise such women in time so that he will spare himself from being responsible for the misery that will almost certainly follow the removal of all the remaining teeth. A toothless woman prematurely aged and disfigured, and her long-suffering family will not soon forget to curse the name of any man who brings such misfortune upon them.

The concluding chapters cover geriatric relationships, saliva, and factors which interfere with normal mastication, nutritional implications, and the physical character of the diet in relation to the health of the supporting tissues.

This book could be profitably read by all engaged in dental practice, particularly prosthetic dentistry.—*N. D. Martin.*

Information from the Dental Board

The following matters are reported from special and ordinary meetings of the Dental Board of New South Wales held on 25th June, 23rd July, 27th August, 26th September and 22nd October, 1952.

APPLICATIONS FOR REGISTRATION.

Morris, Allwyn Lawrence, B.D.S., University of Sydney, 1952. 25/6/52.

Westerman, Miss F. S., B.D.S., University of Adelaide. 23/7/52.

Smith, William Harrison, B.D.S., University of Sydney, 1951. 27/8/52.

Lewis, Harry Keith, B.D.S., University of Sydney, 1951. 22/10/52.

Ward, Stanley Albert, B.D.S., University of Sydney, 1952. 22/10/52.

RESTORATIONS TO REGISTER.

Mumford, George; O'Keefe, Timothy Desmond; McKenzie, James Gordon; Davies, Phillip; James, Casper; Hutchinson, William Frank.

ADDITIONAL QUALIFICATIONS AND DESCRIPTIONS.

Lyell, J. S., M.D.S., University of Sydney; Dunworth, F. D., D.D.S. (Northwestern), 1952.

At its meeting on 23rd July, 1952, the Board considered the matter of additional qualifications and descriptions and, in an endeavour to clarify Board procedure when dealing with applications for permission to use additional descriptions, the Registrar submitted a statement for consideration. It was decided to permit members to study this closely for discussion at the next meeting.

Further consideration was given to this matter on 27th August, 1952, when the Board decided that in future it would give specific authority for alterations to the Register under Sections 6 (1) (d) and/or 6 (1) (e).

FOREIGN DENTISTS.

At these various meetings a number of applications for registration by dentists with foreign degrees were given due consideration and in three of the cases the Board has decided that it is unable to grant the application.

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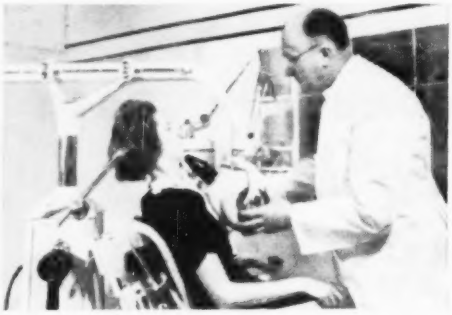

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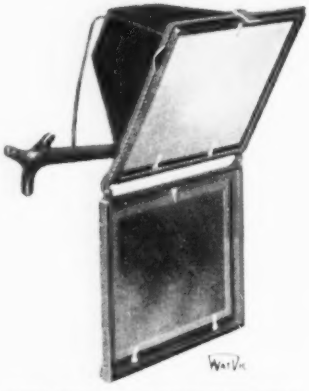

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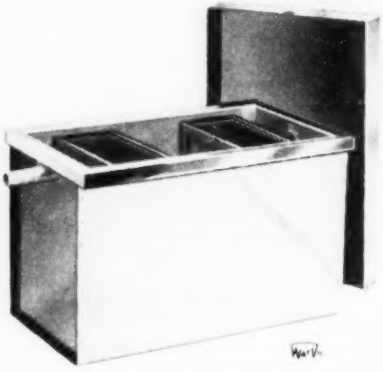

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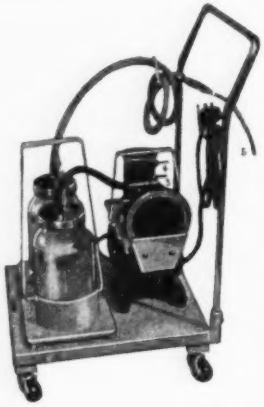

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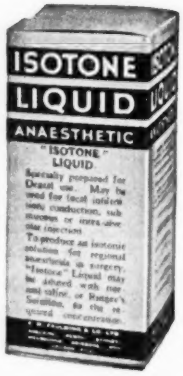

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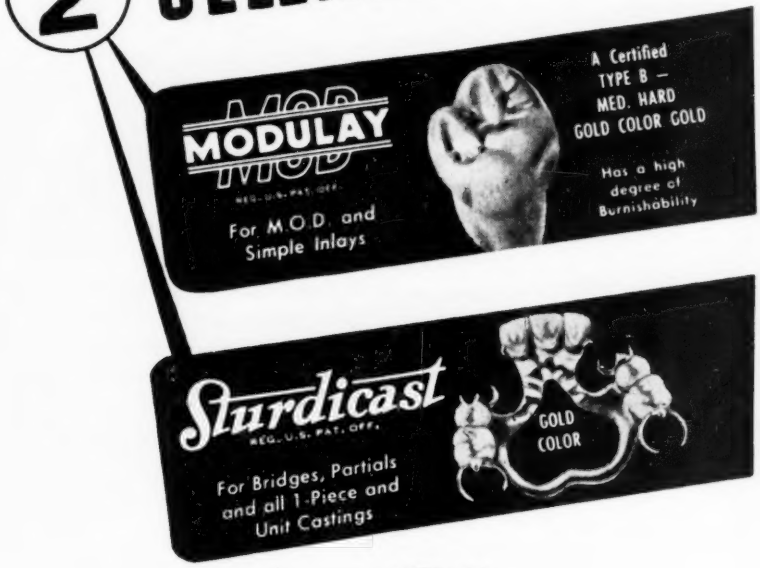
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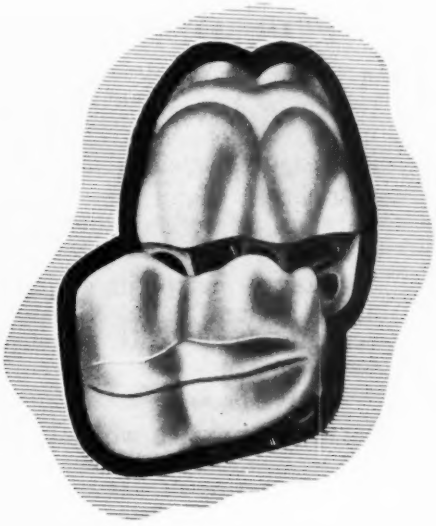

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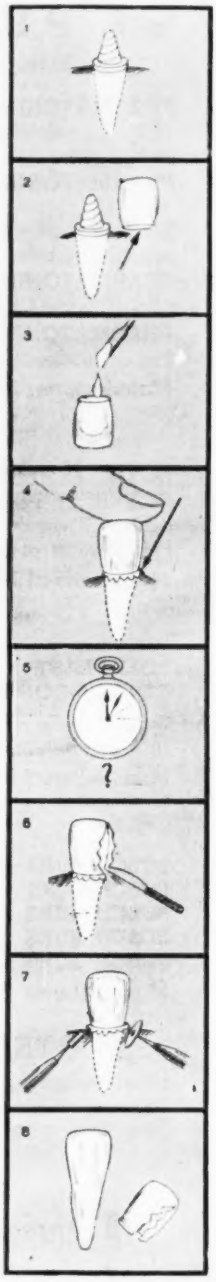

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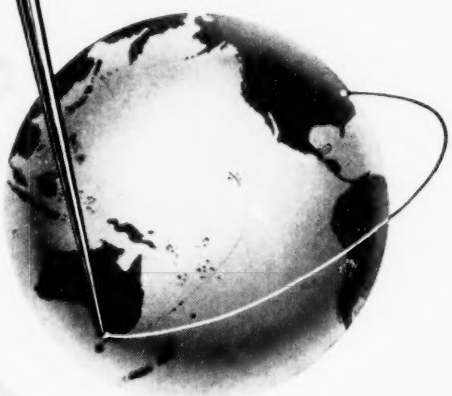

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